Thematic Analysis of Key Recommendations from Commissioned Occupational Health and Safety Reports in Mining

by

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Abstract

The purpose of this research was to review the commissioned occupational health and safety (OHS) reports in mining, over the past 50 years, in a two-step approach. The objective of the initial phase was to determine if there were any recommendations that were stated in more than one of the evaluated commissioned reports, that spanned the 50-year timeframe. The reports were selected through a review of the literature and in consultation with experts in OHS and mining. A multi-stage analysis was conducted on the recommendations, and identified 6 overlapping themes, and 49 sets of specific overlaps. In the second phase, a seeded analysis using a qualitative data analysis software, was completed to understand how safety culture was discussed in the reports. This was accomplished by completing a review of the literature to define safety culture, and to build the dictionary, which was seeded into the software. The analysis highlighted the use of various terms for safety culture throughout the 50-year history, with a particular emphasis on the fact that the term safety culture was not directly referenced in the selected reports until 1997.

Keywords: Mining; Occupational Health and Safety; Accident Investigation; Commission Recommendations; Leximancer; Safety Culture

Co-Authorship Statement

The project was conceptualized in consultation with Dr. Eger, Dr. Pegoraro, Dr. Dorman and Mr. Pakalnis. Data analyses were conducted by E. Tetzlaff with feedback provided by Dr. Pegoraro. E.Tetzlaff completed the associated literature review and wrote the complete first draft of paper 1 (Chapter 3) and paper 2 (Chapter 4). Dr. Eger, Dr. Pegoraro and Dr. Dorman and Mr. Pakalnis provided feedback and editorial guidance on the writing of all chapters.

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Table of Contents

CHAPTER 3: Analysis of Recommendations from Occupational Health and Safety Mining Commissioned Reports: A 50 Year Review

CHAPTER 4: Analysis of Safety Culture in Occupational Health and Safety Mining Commissioned Reports: A 50 Year Review

CHAPTER 5: Discussion

List of Tables

List of Figures

List of Appendices

Glossary of Abbreviations and Terminology

Abbreviation Long Form

CAQDAS	Computer Assisted Qualitative Data Analysis Software
OHS	Occupational Health and Safety
OHSA	Occupational Health and Safety Act
ILO	International Labour Organization
SCSR	Self-Contained Self-Rescuer
IMFR	International Mining Fatality Database
CCOHS	Centre for Occupational Health and Safety
IRS	Internal Responsibility System
HSE	Health and Safety Executive
BBSM	Behaviour-Based Safety Management
PPE	Personal Protective Equipment

Terminology and Definitions

Conceptual Analysis: the detection and quantification of predefined concepts within the text (Version 4.0, 2011, Leximancer Pty Ltd., University of Queensland).

Corpus linguistics: a word can be defined by its context in usage (Smith & Humphreys, 2006).

Data mining: an automated approach to identifying patterns in sets of data (Indulska & Recker, 2008).

Frame: a device that reflects a pattern of cognition, interpretation, and presentation (Gitlin, 1980), and are therefore indicative of broad conceptual categories, that provide culturally specific meaning to the reader (Goffman, 1974; Zaharopoulos, 2007).

Profiling: A method for taking a prior set of concepts of interest and discovering a set of related concepts that depend either strongly or weakly, either directly or indirectly, on the prior concepts (Smith & Humphreys, 2006).

Relational analysis: measurement of relationships between identified concepts within text (Version 4.0, 2011, Leximancer Pty Ltd., University of Queensland).

Seed(ing): Concept seed words represent the starting point for the definition of such concepts, with each concept definition containing one or more such seeds. These seed words can either be provided by the user, or can be automatically extracted from the text. They are called seeds as they represent the starting point of the concept, with more terms being added to the definition through learning. (Version 4.0, 2011, Leximancer Pty Ltd., University of Queensland).

CHAPTER 1

1.0 INTRODUCTION

This chapter will provide an introduction to the mining industry, common occupational hazards in mining, an overview of accident statistics in mining, and will conclude by outlining the overall objectives of the thesis.

1.1 MINING INDUSTRY

Mining currently accounts for 1% of the global workforce, approximately 30 million workers, but is responsible for 8% of fatal accidents at work (ILO, 2016). Fatalities, injuries, and occupational disease are still prevalent among miners, and places mining as one of the most hazardous occupations in the world (Stephens & Ahern, 2002). Mining broadly relates to the extraction of naturally occurring minerals by processes such as underground mining, open-cut extraction methods, quarrying, operation of wells, or evaporation pans, and dredging or recovering from ore dumps or tailings (Hamrin, 1980). A major component increasing hazards in the mine environment is the constantly changing workplace circumstances, with the most severe changes including, but not limited to: the darkness of an environment without natural light where visibility can be reduced to zero; atmospheric air changes due to forced ventilation in the work areas, where the air components can quickly become contaminated and poisonous to the worker; and the constant threat of potentially unstable ground control, as a result of mineral extraction. Although substantial progress has been made in the control of these occupational health and safety (OHS) hazards, including: hazard recognition, legislation, and regulations, more work is required. This includes further analysis of current recommendations, to reduce occupational accidents for miners.

1.2 COMMON HAZARDS ASSOCIATED WITH MINING

The International Mining Fatality database (IMFD) was created by the International Labour Organization (ILO) to establish a global record of all 'incidents causing fatalities' in the last 142 years; with the majority of the data is from 1980-2008 (when reporting regulations were strengthened) (MacNeill, 2008). According to the IMFD (2008), the dominant agents of fatality in mine operations included: asphyxiation, catastrophic failure, contact with moving equipment, drowning, electrocution, explosives, falls from heights, fire, gas ignited explosion, inrush, outbursts, uncontrolled release of energy, and unintended operation of equipment. This database shows that falls from heights accounted for approximately 24% of all mining fatalities, and unintended operation of equipment accounted for 13%. In addition, 77% of all mine accidents resulting in a fatality involved equipment, predominantly trucks (9.2%) and load haul dumps (8.7%) (MacNeill, 2008). The majority of fatalities occured within the mining area at underground mining operations (82%), and production activities accounted for the greatest percentage of all mining fatalities (70%) (MacNeill, 2008). In addition to the physical hazards, there are numerous occupational health hazards in mining. These occupational hazards are often more difficult to recognize as they are not always linked to immediate fatality or injury. Donoghue (2004) completed an extensive review of occupational health hazards in mining and identified five major priority categories: physical, chemical, biological, ergonomic, and psychosocial (Figure 1.1). More recently, in 2015 there were hundreds of traumatic fatalities in the mining industry, including the United States (n=28), Canada (n=5), the United Kingdom (n=1), Australia (n=12), and New Zealand (n=5) (MSHA, 2016; WSN, 2016; United Kingdom Government, 2016; SafeWork AUS, 2016; WorkSafe NZ, 2016). Understanding the occupational hazards and the dominant agents of fatalities present in the mining industry

provides the information needed to recognize the hazards that may arise in the analysis of the selected reports and recommendations.

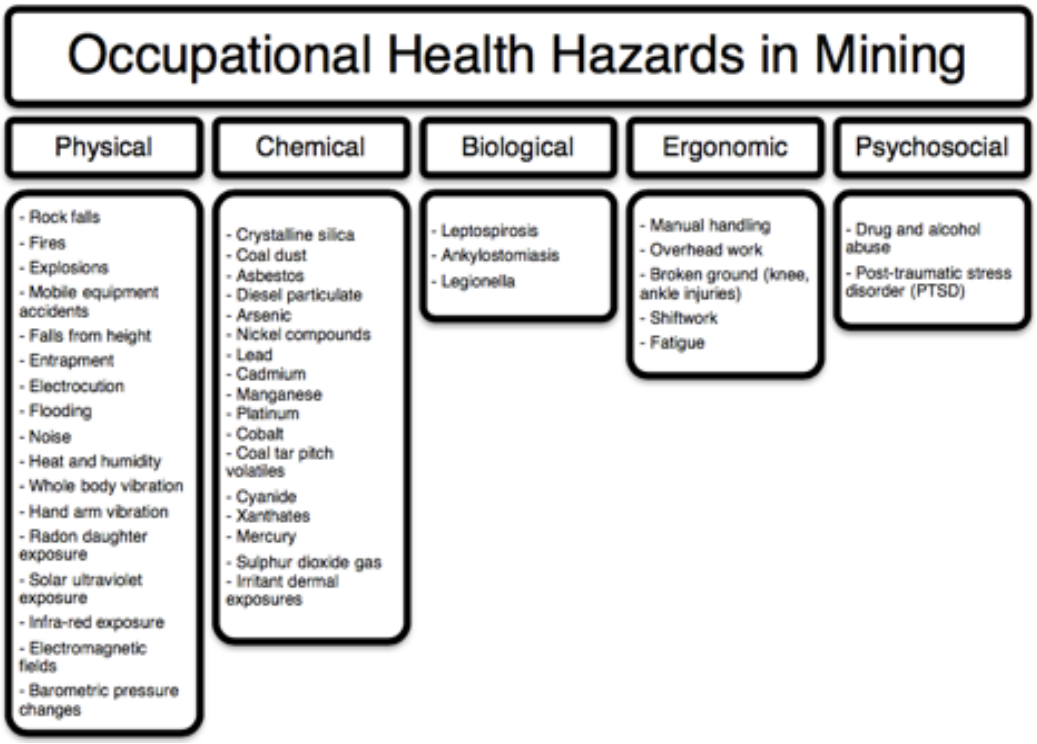

Figure 3.1: Schematic overview of the occupational health hazards identified in an in-depth review by Donoghue (2004) adapted by Tetzlaff.

1.3 THESIS OUTLINE

The overall purpose of this thesis is to review the commissioned OHS reports in mining, over the past 50 years, in a two-step approach (Figure 1.2). First, to determine whether there are any recommendations consistently identified in OHS commissions and reports; regardless of time or geography. Second, to investigate how safety culture has been framed in the reports.

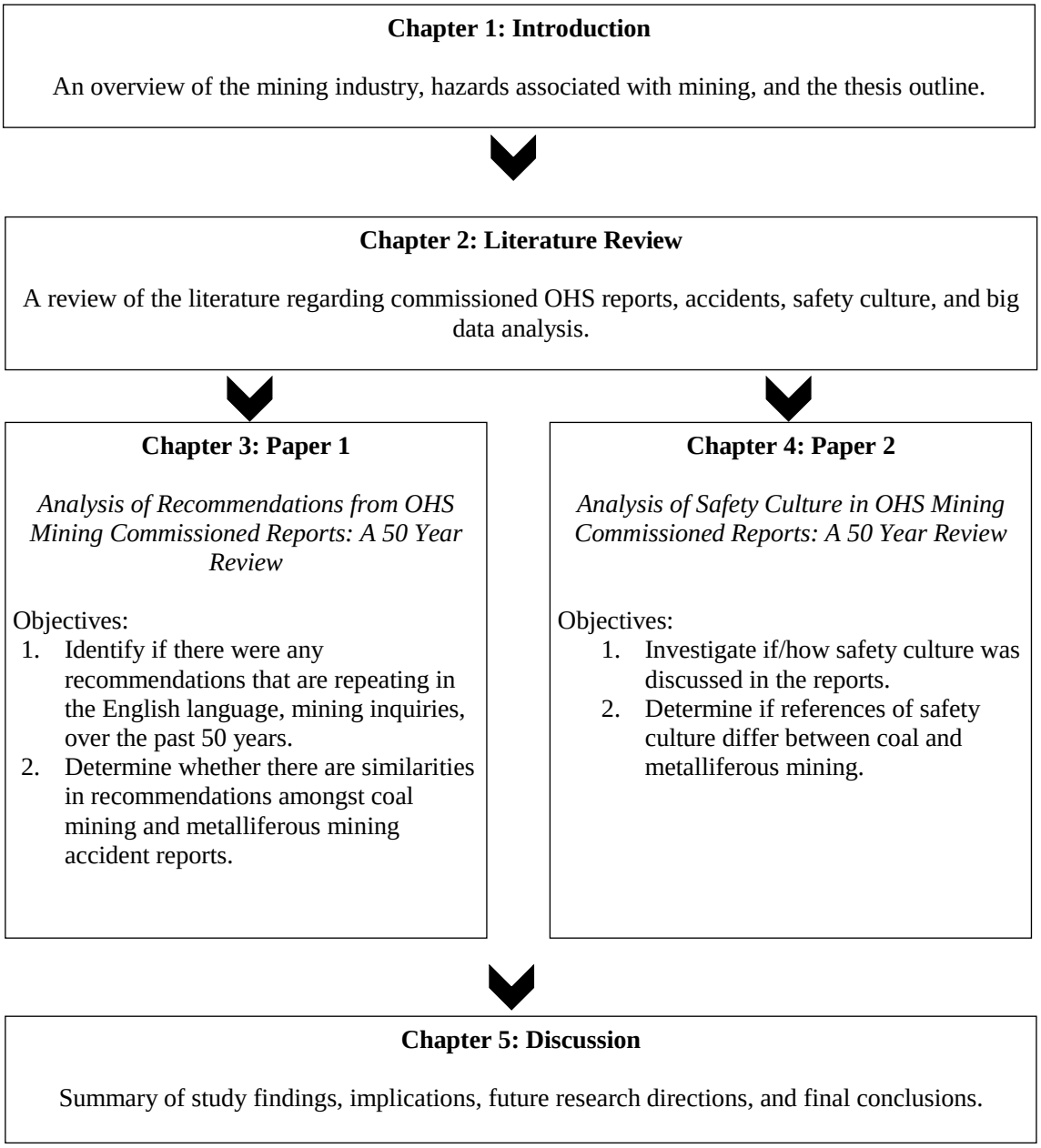

Figure 1.2: Overview of the relationship between the papers to be completed for Master's thesis.

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CHAPTER 2

2.0 LITERATURE REVIEW

This chapter will provide a summary of literature pertaining to accidents, safety culture, and big data analysis. The first section will provide the background on accident literature including: risk assessments, accident causation models, and accident investigation frameworks, followed by a focus on the formulation and role of commissioned reports in mining OHS. The second section provides the background review for safety culture and its roots in organizational culture and organizational climate. The third section, will introduce CAQDAS, and provide background information to illustrate how this software can be used to explore a data set from both a high-level view and to address specific details contained within a document. Further, a discussion on the use of visual text analytics and concept mapping techniques will be included to demonstrate how visual representations of concept space can be used to review the global scope of the underlying domain. The final section will conclude by reviewing the gaps in the literature and outlining the research objectives for this thesis. The aim of this chapter is to provide context and justification for the current research.

2.1 COMMISSIONED OHS REPORTS

Following a major accident, there are different levels of public inquiry that can be established. Types of inquiries include: Coroner's Inquests, Reviews, Commissions of Inquiry, Tribunals of Inquiry and Royal Commissions. A Coroner's Inquest is a public hearing designed to focus public attention on the circumstances of a death through an objective examination of

facts. At the conclusion of an Inquest, recommendations are made that may prevent deaths in similar circumstances (Government of Ontario, 2016; Leveson, 2001). Reviews are generally conducted as comprehensive examination of a particular industry, region, or site, that includes a number of topics, and seeks strategic input from advisory groups in industry, ministry, public or stakeholders (Government of Ontario, 2016). Commissions of Inquiry are established by a Government Cabinet to fully and impartially investigate issues of national importance. The findings and recommendations from a Commission of Inquiry are not binding; however, they often have a significant impact on public opinion and public policy (Government of Canada, 2016c). Tribunals of Inquiry are official reviews of events or actions ordered by a government body. Tribunals of Inquiry differ from other commissions because they are conducted in a more public forum and focus on a more specific occurrence, opposed to numerous occurrences grouped together. Lastly, Royal Commissions are temporary, ad hoc bodies with impartial members from outside of the government (i.e. non-legal professionals and field experts) (Prasser, 2006). Royal Commissions are generally established to investigate new and emerging issues, provide advice on an area where government lacks expertise, access external knowledge, and identify key issues on policy problems (Prasser, 2006). Royal Commissions can be distinguished from other types of inquiry because they are typically, formally appointed by the Crown, rather than by a Minister or Cabinet. Further, many countries establish Royal Commissions under specific legislation and therefore they have greater power, in comparison to other forms of inquiry (Prasser, 2006). Royal Commissions are therefore "by virtue of their membership, statutory base, powers, and formal appointment by the Crown; are the most prestigious of executive inquiries" (Sherman, 1997, p.6). This thesis will pay particular attention to Royal

Commissions. The ability to distinguish between the levels of inquiry is important for understanding the severity of the event, and the scope of the inquiries referenced in this study.

The specific terminology and requirements for establishing a Royal Commission varies between countries. Table 2.1 indicates the commission title, governing legislation and an explanation for five countries. Understanding who produced the commission, and under which legislation it is being conducted is critical for considering the potential directed focus of the report or recommendations that are presented. Royal Commissions receive frequent criticism and are often viewed as a means of demonstrating political expedience, such as showing concern about an issue, giving an illusion of action, demonstrating responsiveness, reducing opposition, and delaying decision-making (Prasser, 2006). Therefore, the continued use of Royal Commissions has caused debate on why, and in what circumstances, governments resort to Royal Commissions over less formal and non-statutory forms of public inquiry (i.e. committees, working groups, and reviews).

Despite the political debate, Royal Commissions can provide the "means for defusing an issue, clarifying a problem, and providing recommendations that have a greater chance of being accepted" (Prasser, 2006, p.45). Specifically, in health and safety there have been numerous commissioned reports produced over the years that have reviewed industrial accidents, and have published recommendations for change. In some cases, the recommendations have heavily influenced the health and safety legislation of the country, state or province. For example, the 1976 Report of the Royal Commission on the Health and Safety of Workers in Mines introduced the concept of the internal responsibility system, which provided the foundation for the Ontario Occupational Health and Safety Act in 1979. However, in other cases we see repetition of recommendations that provide only temporary solutions for greater organizational malfunctions.

Hopkins (2002, p.7) provided an example of this in the context of reporting systems, "the issue is not whether the organization has a reporting system; it is whether, *as a matter of practice*, errors and near misses are reported." Therefore, considering the political climate is important for understanding how and why a commission was established.

Table 2.3: Country specific legislation for establishing royal commissions

COUNTRY	**CANADA**	**UNITED STATES**	**UNITED KINGDOM**	**NEW ZEALAND**	**AUSTRALIA**
TITLE	Royal Commission	Presidential Commission	Royal Commission	Royal Commission	Royal Commission
LEGISLATION	Public Inquiries Act	Federal Advisory Committee Act 1972	Tribunals and Inquiries Act 1921	Inquiries Act 2013; Previously the Commission of Inquiry Act 1908	Public Governance, Performance and Accountability Act; previously known the Royal Commissions Act 1902
EXPLANATION	A panel of experts appointed by the Cabinet to carry out investigations of national concern (Government of Canada, 2016c)	A special task force appointed by the President to complete the investigation (United States Department of Labour, 1972)	An ad-hoc formal public inquiry and is established by the Head of State, on the advice of the government (United Kingdom Government, 2013)	Governor-General can issue commissions without any statutory authority because they are the Chief Executive Office (Government of New Zealand, 2013b)	The highest form of inquiry and are inquired by the Governor-General (Government of Australia, 2013)

2.1.1 Authorities Responsible for OHS in Five Mining Countries

Canada

In Canada, the OHS legislative authority is divided between federal and provincial jurisdictions, as dictated by the Constitution Act (LEGOSH, 2013b; Government of Canada,

1867). The federal act that governs OHS Regulations is the Canada Labour Code (Government of Canada, 1985). The federal legislation applies to companies or sectors that operate across provincial or international borders. This comprises approximately 10% of the Canadian workforce (Government of Canada, 2016a). On the federal level, Human Resources and Social Development Canada (HRSDC) is responsible for developing OHS policies, and the Canadian Centre for Occupational Health and Safety (CCOHS) is then responsible for disseminating the information, and providing education and training (CCOHS, 2016). Provincial or territorial governments are responsible for the legislation, administration and enforcement of OHS within their jurisdiction; the legislation is typically referred to as the OHS act (Ontario MOL, 1990). In Ontario, the OHS act is founded on the Internal Responsibility System (IRS), which legislates that everyone in the workplace has a role in keeping the workplace safe and healthy (Government of Ontario, 2016a). Further, it means that all employees have a statutory duty to report any unsafe situation to their employer or supervisor, and that the employers or supervisors are required to address the situation (Government of Ontario, 2016). The three basic elements of the IRS system are: the right to know, the right to participate, and the right to refuse unsafe work. The IRS is further supported by health and safety policies and programs, such as the *Five-Point Safety System* which is one of the most widely-recognized safety programs in mining (George, 1942; WSN, 2016). Furthermore, the primary regulation specific to OHS in the Ontario mining industry is the Mines and Mining Plants Regulation (R.R.O. 1990, Reg.854) (Table 2.2).

United States of America

In the United States of America (USA), federal and state statutes (LEGOSH, 2013e) primarily regulate OHS. The federal agency responsible for developing and enforcing workplace

health and safety standards is the Occupational Safety and Health Administration (OSHA, 2016), an agency within the Department of Labour (United States Department of Labour, 2016b). The primary law protecting the health and safety of workers is the Occupational Safety and Health Act 1970 (United States Department of Labour, 1970), which is governed by the Secretary of Labour and the Occupational Safety and Health Review Commission (OSHRC). OSHRC is responsible for the administration, enforcement, regulations and performance of inspections and investigations for all workplaces (United States Department of Labour, 2016a; 2016b). In addition, there are a number of regulations specific to the mining industry, including the Mine Improvement and New Emergency Response (MINER) Act of 2006, which was previously known as the Federal Mine Safety and Health Act of 1977) (United States Department of Labour, 2006) (Table 2.2).

United Kingdom

The Health and Safety Executive (HSE), is the governance body that is responsible for OHS legislation and regulations in the United Kingdom (UK) (LEGOSH, 2013d). The HSE works within the Health and Safety Commission (HSC) and is directly linked to the government (UK Government, 2016). The HSE is also connected to the European Agency for Safety and Health at Work (EASHW, 2016). The primary legislation in the UK is the Health and Safety at Work Act 1974 (HSWA), but is supported by more than 200 other OHS related acts and regulations (UK Government, 1974). The UK is currently undergoing a transition to reflect the European directives on health and safety, including the Management of Health and Safety at Work Regulations (UK Government, 1999). In the United Kingdom, the primary regulation

specific to OHS in the mining industry is the Mines Regulation 2014 (MR14) (United Kingdom Government, 2016) (Table 2.2).

Australia

In Australia, the regulation of OHS legislation is shared by: The Commonwealth, the states, and the territories (LEGOSH, 2013a). There are nine general work health and safety statutes in Australia. The Commonwealth statute encompasses all Commonwealth government departments, agencies and authorities, and states and territories each have separate legislation (Government of Australia, 2016a). Australia has recently moved to standardize legislation, and the Australian Workplace Relations Ministers Council (WRMC) has implemented a Model Work Health and Safety bill (WHS) (Government of Australia, 2016a). The WHS legislation includes a model WHS Act, regulations, Codes of Practice and a national compliance and enforcement policy. Two federal agencies that influence OHS are: SafeWork Australia (SWA) and the Australian Safety and Compensation Council (ASCC). The SWA is the national body in charge of developing work health and safety policies (Safe Work Australia, 2016). The ASCC acts as a federal body that can declare standards and codes of practice, but these need to be adopted by states and territories before they have legal power (Government of Australia, 2016a). Furthermore, there are a number of regulations specific to the mining industry, including the Workplace Health and Safety (Mines) Regulations (Government of Australia, 2011) (Table 2.2).

New Zealand

New Zealand's health and safety legislative framework is primarily regulated by the Health and Safety and Employment Act 1992 (HSE) (LEGOSH, 2013c). The HSE Act is modeled after the United Kingdom's Roben's Approach, which places each person responsible

for managing hazards in the workplace (Robens, 1972). In addition to the HSE Act, there are two additional Acts that are principal regulators of OHS. The Accident Compensation Act is the foundation of New Zealand's compensation and rehabilitation system (Government of New Zealand, 2016). The Hazardous Substances and New Organisms Act (HSNO) ensures, that people are not harmed by exposure to harmful substances (Government of New Zealand, 1996). These three main Acts are supported by a number of additional Acts and regulations that influence workplace health and safety. The Ministry of Business, Innovation and Employment governs the HSE Act. Compliance to the HSE Act is monitored and enforced by the Department of Labour inspectors (Government of New Zealand, 2016). The primary regulation specific to OHS in the mining industry is the Mining Operations and Quarrying Operations Regulations 2013, which was previously known as the Health and Safety in Employment Mining Administration Regulations 1992 (Government of New Zealand, 2013a) (Table 2.2).

Having an understanding of the regulations specific to OHS, and the mining industry, for each country, provides the background for exploring the legislative recommendations that resulted from the inquiries. Further, it will provide context for understanding how the terminology may vary between country, along with providing a frame of reference for the organizational and regulative bodies involved in the discussion.

Table 4.2: Summary of minerals, workforce, primary regulations, legislation, and agencies specific to OHS in the mining industry in five countries.

	CANADA	UNITED STATES	UNITED KINGDOM	NEW ZEALAND	AUSTRALIA
MINERALS	Extracts more than 60 minerals and metals, including: gold, nickel, copper, salt, diamonds and structural building materials (Mining Association of Canada, 2016)	Extracts more than 14,000 mines extracting coal, metal ores and non-metallic minerals (MSHA, 2016)	One of the largest dredging industries in the world and marine-source aggregates make a vital contribution to the UK aggregate supply for construction, coastal protection, and land reclamation (LEGOSH, 2013d)	Produces abundant mineral resources including: coal, gold, iron sands, phosphate and limestone (LEGOSH, 2013c)	world's largest producer of: lead, mineral sands, nickel, silver, tantalum, uranium and zinc (LEGOSH, 2013a)
WORKFORCE	370,000 workers (Mining Association of Canada, 2016)	634,000 workers and provides 1.27 million jobs in allied industries (United States Department of Labour, 2016b)	3,950 workers (UK Government, 2013)	2,000 workers (LEGOSH, 2013c)	750,000 Workers (Australian Bureau of Statistics, 2016)
PRIMARY MINING REGULATION	Mines and Mining Plants Regulation (R.R.O. 1990, Reg.854) (Government of Canada, 2016b)	Mine Improvement and New Emergency Response (MINER) Act of 2006; Previously the Federal Mine Safety and Health Act of 1977 (United States Department of Labour, 2006)	Mines Regulation 2014 (MR14) Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013 (HSE, 2016)	Mining Operations and Quarrying Operations Regulations 2013; previously the Health and Safety in Employment Mining Administration Regulations 1992 (Government of New Zealand, 2013a)	Workplace Health and Safety (Mines) Regulations (Government of Australia, 2011)
LEGISLATION	Occupational Health and Safety Act (Government of Ontario, 1990)	Code of Federal Regulations (30 CFR Part 50) (United States Department of Labour, 2016a)	Health and Safety at Work Act 1974 (UK Government, 1974)	Health and Safety and Employment Act 1992 (HSE) (LEGOSH, 2013c)	Model Work Health and Safety bill (WHS) (Government of Australia, 2016a)
REGULATING AGENCY	Ministry of Labour (Government of Ontario, 1990)	Mine Safety and Health Administration (MSHA) (MSHA, 2016)	Health and Safety Executive (HSE) (HSE, 2016)	Ministry of Business, Innovation and Employment (Government of New Zealand, 2016)	Ministerial Council on Mineral and Petroleum Resources (Government of Australia, 2009)

2.2 ACCIDENTS

Accidents are the product of the dynamic interaction between human and organizational factors, including: managerial, technological, and environmental factors in the presence of weakness or gaps in the systems barriers (Clarke, 2006; Bjerkan, 2010). Reason (1998), provides a further explanation for the distinction between individual and organizational accidents:

> *"the most critical distinction…lies in the quantity, quality and variety of the defenses, barriers and safeguards that protect people and assets from the local operational hazards. Individual accidents occur in circumstances where the hazards are close to people and the defenses are limited or non-existent. Organizational accidents, on the other hand, happen to complex systems that have defenses-in-depth-that is, protective measures possessing a great deal of diversity and redundancy." (p.295)*

Organizational accidents are usually low-frequency events and are typically triggered by unintentional errors, made possible by preexisting hazards or pathogens that have made the system vulnerable to failure (Reason, 1990). There are numerous organizational factors that influence accidents, including: the quality of communication (Hofmann & Morgeson, 1999; Mearns, Whitaker & Flin, 2003), the influence of organizational climate (Neal, Griffin & Hart, 2000), leadership style (Kim, Park & Park, 2016; Zohar, 2002; Barling, Loughlin & Kelloway, 2002), management practices (Flin et al., 1996), occupational stressors (i.e. role conflict, role ambiguity) (Hemingway & Smith, 1999; Gillen et al., 2002; Goldenhar, Williams & Swanson, 2003), job demands (i.e. production pressure, role overload) (Clarke & Cooper, 2004), and psychological and behavioural characteristics of the individual (Oliver et al., 2002; Clarke,

2006). Understanding the difference between individual and organizational accidents, and the factors that influence them is essential for understanding the events that triggered the commissions to be established.

2.2.1 Risk Assessment

Risk assessment is the process of identifying hazards, analyzing and evaluating the risk associated with the hazards, and determining the appropriate method of eliminating or controlling the hazards (CCOHS, 2016). Risk assessments are a core part of OHS management that serve multiple purposes, including: creating awareness of hazards and risk; identifying who is at risk, determining if existing control measures are adequate, preventing injuries or illnesses, and prioritizing hazards and control measures (CCOHS, 2016). Following the identification of hazards, a level of risk can be allocated based on product information, past experience, legislated requirements, industry codes of practice, health and safety material, and results of testing. Additional factors can contribute to the level of risk, such as: the work environment, the capability, skill and experience of workers, and systems of work (CCOHS, 2016). After allocating a level of risk, prioritizing the hazards can determine which is the most serious and should be controlled first. Prioritization may be influenced by: percentage of workforce exposed, frequency of exposure, degree of harm likely to result from the exposure and probability of occurrence (CCOHS, 2016). Following the identification of hazards control mechanisms can be applied, including: elimination, substitution, engineering controls, administrative controls, and personal protective equipment (Figure 2.1) (NIOSH, 2016). Understanding the hazards present in mining, and the hierarchy of the mechanisms used to

control these hazards is important when addressing how the recommendations were formulated, and which tier of control mechanisms were targeted.

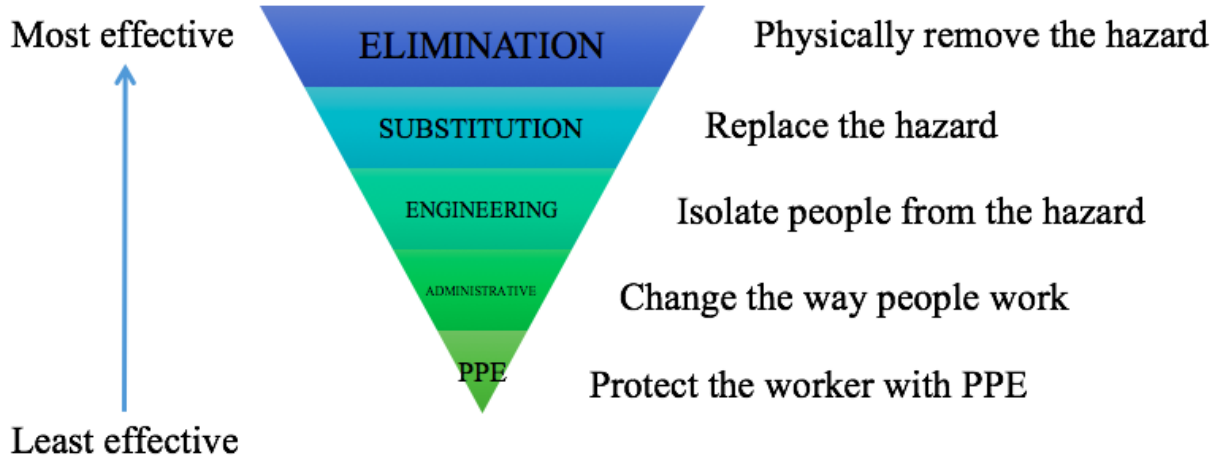

Figure 4.1: Tetzlaff (2016) adapted model of hierarchy of controls and risk control effectiveness

2.2.2 Accident Causation

Accident causation models explain possible mechanisms for the accident occurrence, regardless of the specific setting (Kataskiori, Sakellaropoulos & Manatakis, 2009). Accident causation models recognize the reciprocal relationship between psychological, situational, and behavioural factors (Cooper, 2000), and how these causal factors can be traced to identify root causes (Goh, Brown & Spickett, 2010). Knowledge of accident causation is important for understanding how the commissions reviewed the events leading up to the accidents.

One of the early accident causation models was the Domino Theory, developed by Heinrich (1941), which suggested that linear one-by-one progressions of events lead to an accident. Often these models cited human error, defined as any one set of human actions that

exceed some limit of acceptability, as the cause of the accident (Rigby, 1970). This model was supported until 1974, when the first modifications were proposed. However, even with modifications, the model was a one-dimensional sequence of events (Kjellén, 1987; HSC, 1993) until Reason (1990) introduced multi-causality to the accident causation process, which related human systems or organizational defenses to a series of barriers. Reason (1990) described accident causation as an interaction between latent and active failures, where active failures are "the immediate, observable causes in an accident which are easily identified" and latent failures are caused by organizational factors that may be present in a system for a long period of time before becoming active failures (i.e. communication, culture, training, resources, etc.) (Figure 2.2).

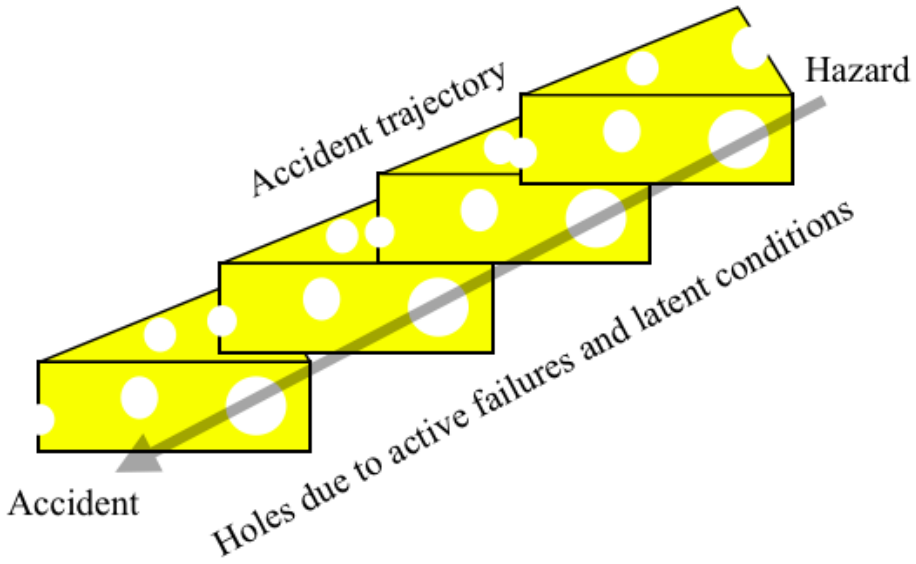

Figure 2.2: Reason (1998, p.296) 'Swiss cheese' model of defences-in-depth adapted by Tetzlaff.

Around the same timeframe, Rasmussen (1987) proposed the Skill-, Rule-, and Knowledge-framework, which is based on behaviour and human cognitive control of the environment. Hale and Glendon (1987) then combined Reason and Rasmussen's frameworks and developed the Attribution Theory. This theory proposes that danger is always present in the

workplace, and conceptualizes the role of human action in controlling danger. Rasmussen (1997) then presented a multi-level model of a socio-technical system that states that safety performance is influenced by internal (safety culture) and external factors (regulation and government). In the same year, Reason (1997) developed a model of organizational accident causation, which demonstrated the influence and pathway of latent failures and outlined three levels of concern: the organization, the workplace, and the person. Reason's model has since been applied in industrial settings, through the development of proactive measures for organizational processes known to be implicated in accident causation. Further, it has been applied in accident investigation techniques that guide investigators and analysts to the organizational root causes of past accidents. Lastly, Hollnagel (1998) proposed the cognitive reliability and error analysis method, which distinguished between causes and effects and described the full context in which errors and accident occurs.

The evolution of accident causation models described above indicates a shift in understanding from a basic outline of the sequence of events, to a broader representation of the whole system (Kataskiori, Sakellaropoulos & Manatakis, 2009). It is also important to acknowledge that, "an accident can be explained in different ways depending on the accident analysis model that is used" (Svenson, 1999). Different models focus on different aspects of accident causation and as a result may be associated with different recommendations for improvement (Kataskiori, Sakellaropoulos & Manatakis, 2009; Lundberg, Rollenhagen & Hollangel, 2009). Therefore, the choice of causation model is critical to how an accident is investigated, because different accident causation models will influence different accident investigation outcomes, under altered circumstances. Reviewing the evolution of accident causation models is important for this thesis because the reports cover a large historical

landscape, and therefore the causation theories that were applied to the inquiries changed over time.

2.2.3 Accident Investigation

The outcome of an accident analysis depends not only on the view on causality, discussed previously, but on what factors are included as causes and contributing factors, and which are omitted (Lundberg, Rollenhagen & Hollangel, 2009). Accident investigation methods are very specific and have been primarily developed for use in major accidents, in technologically complex systems (Kataskiori, Sakellaropoulos & Manatakis, 2009). Although differences may exist between how countries conduct investigations, generally in all cases, it is government agencies or their representatives who conduct the accident investigations (LeCoze, 2013). Dekker (2015) identified four purposes of accident investigations: (1) epistemological (i.e. establishing what happened); (2) preventive (i.e. identifying pathways to avoid future accidents); (3) moral (i.e. tracing the transgressions that were committed and reinforcing moral and regulatory boundaries); and (4) and existential (i.e. finding an explanation for the suffering that occurred). The overarching intention is to avoid a reoccurrence of an accident rather than to establish blame (Vuorio et al., 2013).

Primary methods of accident investigation include: Fault Tree Analysis (Ferry, 1988), Management Oversight and Risk Tree (Johnson, 1980), Multilinear Events Sequencing (Benner, 1975), Systematic Cause Analysis Technique (Kjellén & Hovden, 1993), Causal Tree Method (Leplat, 1978), TRIPOD (Wagenaar et al., 1994), Accident Evolution and Barrier Function (Svenson, 1991), Integrated Safety Investigation Methodology (Ayeko, 2002), Norske Statesbaner (Skriver, Haukenes, & Alme, 2003), and Control Change Cause Analysis (Kingston, 2007) (Appendix A), to name a few. Similar to accident causation, acknowledging that there is

an array of accident investigation techniques available to industry is important for understanding that there are various approaches to investigate an accident, and therefore various potential outcomes.

The evolution of accident investigation methods over time also demonstrates a shift from isolating a single immediate cause, to acknowledging multiple causes. This drives the elimination of active causes, without impact on reducing latent causes, and therefore does not adequately prevent future accidents (Marais, Dulac & Leveson, 2004; Leveson, 2004). Hovden, Albrechtsen & Herrera (2010) affirmed that most occupational, accident investigation experts still rely on investigation methods that only identify the approximate causes. In addition, Hollangel (2008) refers to the *'What-You-Look-For-Is-What-You-Find'* (WYLFIWYF) principle to explain accident investigations, which has further been expanded to the *'What-You-Find-Is-What-You-Fix'* (WYFIWYF) principle, meaning that the causes identified in an investigation, become the foundation of the formulation of the recommendations for change (Lundberg, Rollenhagen & Hollangel, 2009). Accident investigation techniques, based on theories of accident causation and human error, result in a better understanding of: the relationship between the preceding human behaviour and the accident; therefore, allowing the root causes of the accident to be determined (Brown, 1995). Investigation methods should support the visualization of the accident sequence, provide a structured collection of evidence, and identify recommendations for change (Braut & Nja, 2010). As the reports in this study cover a large historical landscape, reviewing the evolution of accident investigation methods is important to understand how the investigative approach may have changed over time.

2.2.4 Accident Reduction

Industries around the world are showing an increasing interest in the concept of safety culture as a means of reducing the potential for large-scale disasters, and accidents (Cooper, 2000). Safety culture, which is primarily aimed at preventing organizational accidents (as opposed to individual accidents) focuses on the root causes of accidents; not symptoms of accidents, leading to more effective accident prevention strategy (Abdelhamid & Everett, 2000). Accident prevention, as defined by Heinrich, Petersen & Roos (1980) is "an integrated program, a series of coordinated activities, directed to the control of unsafe personal performance and unsafe mechanical conditions, and based on certain knowledge, attitudes, and abilities." In accident reduction, there are two primary sources of data: lagging indicators and leading indicators. Lagging indicators are measurements of past performance, such as injury and incident statistics, whereas leading indicators are proactive measures (i.e. safety audit and safety climate measurements, training rates, preventative maintenance reports, etc.) (Farrington-Darby, Pickup & Wilson, 2005). In high risk industries, the safety culture approach to accident reduction focuses on leading indicators within an organization (Clarke, 1999) which assists in reducing the tendency to blame an individual or group for the incident, and increases the opportunity to identify an effective preventative measure (Goh, Brown & Spickett, 2010). Therefore, safety culture provides a major contribution to the prevention of occupational accidents, and risk reduction.

2.3 SAFETY CULTURE

Safety researchers have traditionally focused on hazard control technologies (DeJoy, 2005), and human factors that are associated with accident-proneness (Greenwood & Woods,

1919; Hansen, 1989; Shaw & Sichel, 1971; Sutherland & Cooper, 1991; Clarke, 2000). However, major disasters, have illustrated the importance of recognizing that accidents are not only a result of human error, environmental conditions, or technical failures, but also a result of breakdowns in policies, procedures and management practices that contribute to system failures (Barling, Kelloway, & Iverson, 2003; Cox & Cheyne, 2000; Hayes et al., 1998; Parker, Axtell, & Turner, 2001). As a result of detailed accident inquiries, the term 'safety culture' emerged in the literature, and has since been identified as a developing area of research, referred to as 'the third age of safety' (IAEA, 1986; Cox & Flin, 1998; Hale & Hovden, 1998). Since the concept was developed, safety culture has begun to be cited in reports and commissions of accidents across multiple industries. However, there is debate on how, or if, safety culture should be measured, monitored and incorporated into accident analysis, pre- or post-investigation.

Across the literature, authors had defined the term safety culture in various ways (Appendix B). The definitions available typically reference the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organization's health and safety management (OSHA, 2015). Reason (1998) simplifies the concept to be a combination of: something an organization is (i.e. beliefs, attitudes, values), and something that an organization has (i.e. practices, policies, controls). The patterns of shared beliefs, attitudes and values that a group maintains are transferred to new members as the correct way to perceive, think, and feel (Hopkins, 2002), thereby propagating the prevailing culture. This self-sustaining nature also indicates that cultures are often resistant to change (DeJoy, 2005). Understanding that there are various definitions of safety culture assists in acknowledging that it is a multi-faceted concept that incorporates a wide range of organizational factors.

2.3.1 Models of Safety Culture

Mirroring the discussion around defining the term safety culture, authors have proposed various models of safety culture. One of the most widely accepted models is Reason's (1997) model, which incorporates five key elements: informed culture, reporting culture, just culture, learning culture, and flexible culture (Figure 2.3).

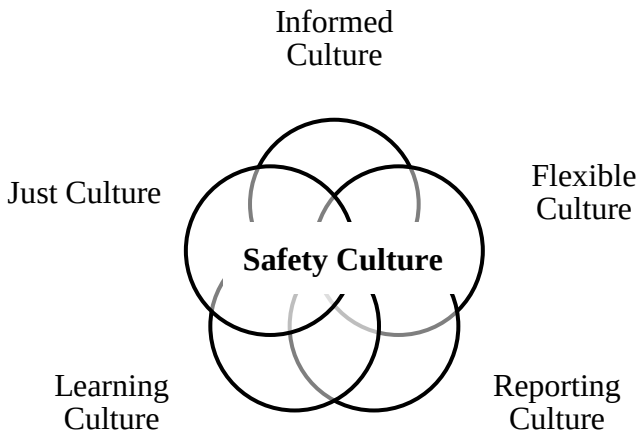

Figure 2.3: Tetzlaff (2017) visualization of Reason's (1997) model of safety culture

The five key elements are all interconnected and influence the success of each other. An informed culture is defined as "a culture in which those who manage and operate the system have knowledge about the human, technical, organizational and environmental factors that determine the safety of the system as a whole" (Reason, 1997). A core aspect of an informed culture is supported by a reporting culture. However, a reporting culture is not based on merely having a reporting system in place, individuals must use it in practice to report errors and near-misses. A reporting culture should maintain confidentiality or the de-identification of reporters; a separation of the department collecting the reports from the disciplinary authority; rapid and

accessible feedback; and ease of reporting. Although these factors are key in supporting a widely-used reporting system, Reason (1998) emphasizes that the most important factor is trust. Therefore, following the reporting culture, is the concept of a just culture. In order for employees to feel comfortable reporting they have to trust that they will be treated fairly by management (Gill & Shergill, 2004). Reason (1998) reiterates that in a just culture the line between acceptable and unacceptable behaviour is clear, and that there is an important distinction between errors and violations. Errors are generally unintended, whereas violations involve a conscious decision. Therefore, violations have motivational and situational origins (Reason, 1998). Violations can be further distinguished between routine violations and necessary violations. Routine violations involve taking the path of least effort between two task-related points, regardless of the procedure (Reason, 1998). Necessary violations stem from inadequacies of equipment or workplace procedures that are required to complete the task, making the individual a victim of circumstance (Reason, 1998). A learning culture refers to the willingness and competence of the organization to draw appropriate conclusions from the reporting and monitoring systems. Finally, a flexible culture refers to the ability of the organizational structure to be reconfigured to accommodate the changing environment. All of the features concern organizational practices, emphasizing that practices are the focal point of safety culture Hopkins (2002). Hofstede and Hofstede (1991) said:

> *"Changing collective values of adult people in an intended direction is extremely difficult, if not impossible. Values do change, but not according to someone's master plan. Collective practices, however, depend on organizational characteristics like structures and systems, and can be influenced in more or less predictable ways by changing these." (p.181)*

Understanding the core elements of safety culture is important for this thesis because as the reports and recommendations are explored, it will provide insight into which themes are repeated and whether or not safety culture was incorporated into the recommendations.

2.3.2 Relationship between safety culture and safety-related outcomes

A strong safety culture is associated with numerous safety-related outcomes, including: performance of safe work practices (DeJoy, Murphy & Gershon, 1995; Griffin & Neal, 2000; Mattila, Hyttinen & Rantanen, 1994), safety program effectiveness (Cheyne et al., 1998; Zohar, 1980), and reduction in accidents, near misses, and other safety incidents (Dedobbleer & Beland, 1991; Gillen et al., 2002). Research has found evidence of these positive safety-related outcomes in a range of hazardous industries (e.g. chemical and nuclear processing) (Lee, MacDonald & Coote, 1993; Hofmann & Stetzer, 1996), high accident-rate sectors (e.g. manufacturing and construction) (Brown & Holmes, 1986; Zohar, 2000; Gillen et al., 2002), and in low accident-rate sectors (e.g. service industry) (Barling, Loughlin & Kelloway, 2002). In contrast, a poor safety culture can adversely undermine a systems protection. Breaches in system defences can often stem from a failure to understand and 'fear' the range of operational hazards present (Reason, 1998). Referencing back to an informed culture, Reason (1998) states:

> *"an informed culture is one in which people, at all levels, do not forget to be afraid. They know where the edge is without having to fall over it….an inability to appreciate the full extent of the operational dangers can lead to the creation of more longer-lasting holes in the defences." (p.302)*

Therefore, by developing a positive safety culture, the organization will be able to identify and defuse latent failures before they breach defence systems, thereby improving safety related

outcomes (Reason, 1998). This is relevant for this thesis because by retroactively looking at accidents there is an opportunity to view the latent failures and apply a safety culture lens to how safety-related outcomes can be improved in the future.

2.3.3 Dimensions of safety culture

In order to avoid the failure of the system, there are various dimensions of safety culture that can be considered. The following section will provide background on eight key dimensions of safety culture: (1) management and leadership, (2) safety systems, (3) risk attitudes and justification, (4) individual responsibility, (5) safety behaviour, (6) safety compliance, (7) safety motivation, and (8) system assessments and monitoring (Christian et al., 2009; Reason, 1998; Mearns & Flin, 1999; Vinodkumar & Bhasi, 2008; DeJoy, 2005; Clarke, 2000). Reviewing the dimensions of a strong safety culture provides further support for highlighting the repetition of recommendations, and how considering safety culture can help improve industry safety.

Management and Leadership

The most widely accepted determinant of an organization's safety culture is the role of management and leadership (Neal & Griffin, 2002; DeJoy, 2005; Kim, Park & Park, 2016). Safety culture is influenced by an organizations ability to manage safety and requires a high degree of control over, and coordination of the processes involving risk. This can be referred to as a top–down organizational approach (Mohamed, 2003; Choudhry, Fang & Mohamed, 2007; Mearns, Whitaker & Flin, 2003; Antonsen, 2009; Hopkins, 2002). Previous research has demonstrated that management's commitment to safety, management style, and management visibility, are key indicators of the safety culture (Flin et al., 2001). Unfortunately, as discussed

by the Roben's committee (1972), because this responsibility is diffused vertically in organizational hierarchies the dependence on senior management can be challenging due to competing concerns with other areas of the organization. Therefore, there must be commitment from all levels of the organizational structure. Understanding management's role, in influencing an organization's safety culture, will provide the ability to analyze and interpret who the commission recommendations were directed towards.

Safety Systems

Major accidents can frequently be traced to failures in safety management systems (Hopkins, 2002). Safety management systems refer to comprehensive business management systems, including: policies, strategies, and procedures, designed to control the risks that may affect health and safety in the workplace (Kirwan, 1998; Fernández-Muñiz, Montes-Peon & Vazquez-Ordas, 2007). Fernández-Muñiz et al. (2007) reported that an adequate safety management system must contain six key dimensions: safety policy, incentives for employee participation, training, communication, planning, and control. Safety management systems can encompass many different aspects of an organization, including: safety officials, safety committees, safety policies, and safety equipment (Flin et al., 2000).

Safety management systems can be viewed as social systems, and therefore rely on employees' behaviour in determining the efficacy of the system (Lee & Harrison, 2000; Choudhry, Fang & Mohamed, 2007). Safety management systems influence behaviour, and behaviour influences the safety management system. Due to this reciprocity, although the safety environment developed by an organization's safety management system is the same for all individuals, the individual's experience is dependent on their perceptions and safety-related

behaviour (Cooper, 2000). Further, influences such as: production pressures, consequences (i.e. rewards/punishment) for compliance or non-compliance, and external influences (i.e. industry, legislature) may influence this reciprocal relationship (Pidgeon, 1997; Cooper, 2000).

Vulnerability in an organization can arise from interactions between preconditions, any of which acting alone, would be unable to challenge the safety system (Pidgeon, 1997). As a result, many industries, such as aviation, design safety management systems with the perspective that there will always be threats to safety (Gill & Shergill, 2004). This view allows the system to ensure that threats are constantly being looked for and managed before an accident occurs. An organization, which has mechanisms to inform itself, will identify these failures; and an organization, which focuses solely on correcting unsafe behaviour, will not (Hopkins, 2002). If the organization has a positive safety culture, the limitations of the safety system will be less influential (Hopkins, 2002). Therefore, understanding the role of safety systems, and the different aspects of an organization that it encompasses, allows for a critical review of the formulation of recommendations that address these systems.

Safety Attitudes

Organizations often try to change individual attitudes without consideration for job and organizational features (Atkinson, 1990). Similarly, changes are often made to organizational systems without regard for individual behaviour or attitudes (Seddon, 1989). Attitude is defined as "a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour" (Eagly & Chaiken, 1993). Attitudes are preceded by cognitive, affective, and behavioural processes, and attitudes produce cognitive, affective, and behavioural responses (Guldenmund, 2000). Therefore, safety attitudes refer to both individual and collective beliefs

about hazards and the importance of safety, together with the motivation to act on those beliefs (Pidgeon, 1991).

Individuals are "neither deterministically controlled by their environments nor entirely self-determining" (Davies & Powell, 1992). This is referred to as a state of reciprocal determinism, where the individual and the environment perpetually influence each other. This model of reciprocal determinism was originally developed by Bandura, and is founded in the Social Cognitive Theory (SCT) (Bandura, 1986) and Social Learning Theory (SLT) (Bandura, 1977). SCT and SLT both explain psychosocial functioning in terms of three reciprocal causal factors: internal psychological factors, the environment, and behaviour. However, the influence applied to each element by the others may not occur simultaneously (Bandura, 1977).

Bandura's model has further been adapted (Cooper et al., 1994; Cooper, 1996) to reflect the concept of safety culture. Researchers have applied Bandura's model to the workplace and proposed that the reciprocal causal factors that form an organizations safety culture are: the attitudes, perceptions and beliefs of individuals, their behaviour's, and the safety management systems (Cooper, 2000). Cooper (2000) also illustrated that safety culture does not operate in a vacuum: it affects, and in turn is affected by, other non-safety-related operational processes or organizational systems. Therefore, understanding the role of individual attitudes, and the reciprocal relationship between the organizational environment and changing attitudes, is important for analyzing if any repeating recommendations are presented in a manner that can achieve the necessary attitudinal and organizational changes.

Internal Responsibility System

The Internal Responsibility System (IRS) refers to the concept that all parties in the

workplace contribute to detecting and correcting workplace issues that can lead to injury and illness (Plummer, Strahlendorf & Holliday, 2000). The IRS first appeared in the literature in 1976 in the Report of the Royal Commission on the Health and Safety of Workers in Mines lead by Dr. James Ham. The IRS then became the underpinning of the Ontario Occupational Health and Safety Act (OHSA) in 1979. Research has since found that individuals at different hierarchical levels have different ways of conceptualizing and prioritizing work safety (Clarke, 1999). In the organizational setting, two types of social supports have been distinguished: supervisory support and co-worker support. Supervisory support is defined as the degree of consideration expressed by the immediate supervisor for the sub-ordinates (Michaels & Spector, 1982). Co-worker support refers to the degree of consideration expressed between co-workers (Blau, 1960). The interaction between social supports is key to the foundation of the IRS. Groups with a greater proportion of members, who are noncompliant with required safety behaviours, accumulate a greater number of contributory causal factors over time (Neal & Griffin, 2006). Therefore, noncompliance with safety procedures and refusal to participate in activities that enhance safety may not directly affect the person that fails to carry out the behaviour, but it may create the condition for someone else to be injured. Responsibilities towards safety have a large influence on the overall safety culture of an organization. Therefore, understanding the IRS assists in addressing the repeating recommendations targeted specifically at responsibilities.

Safety Behaviour

Safe work behaviour is influenced by psychological and environmental factors (Bandura, 1977; Cooper, 2000; Neal & Griffin, 1999). Safe work behaviour is a critical consideration for a

safety management system because culture refers to patterns of behaviour. Therefore, modifying behaviour in an organizational context, by definition, modifies the culture (Hopkins, 2002). When an individual's behaviour is not aligned with their values the individual feels tension, known as cognitive dissonance. Hopkins (2002) explains that *"if the behaviour is determined by the organization then the individual's values will shift accordingly,…if the organization constrains the individual to behave safely, the individual will begin to value safe behaviour more highly" (p.6)*. Further, the behaviour of management and workplace leaders is instrumental in determining the culture of an organization (Hopkins, 2002). Consequently, if the behaviour of managers is modified, there is greater potential for organizational changes (Hopkins, 2002). Although behaviour modification has been seen to reduce accident rates in some cases, other researchers challenge that focusing on behavioural change diverts attention away from the deeper causes of accidents (i.e. understanding why people behave unsafely) (Hopkins, 2000). Therefore, safety behaviour and accidents should be observed at the group level, rather than the individual level (Neal & Griffin, 2006).

The aim of most safe behaviour strategies is to identify behaviour's that are not compliant with safe work procedures (Hopkins, 2002). Behaviour models identify the worker as the main cause of the accident, based on the tendency for humans to make errors under various situations and environmental conditions (Abdelhamid & Everett, 2000). The foundation of most behaviour models is the accident proneness theory (Abdelhamid & Everett, 2000). The accident proneness theory assumes that there are permanent characteristics in a person that make them more likely to have an accident.

Behaviour-Based Safety Management (BBSM) focuses on the identification and modification of critical safety behaviours, and emphasizes how such behaviours are linked to

workplace injuries and losses (DeJoy, 2005). Secondly, it emphasizes the fundamental importance of the organization's safety culture and how it shapes and influences safety behaviours and safety program effectiveness (DeJoy, 2005). BBSM can be viewed as an extension of applied behaviour analysis, and draws on theories and practices of operant conditioning and reinforcement theory. BBSM is a bottom-up approach that begins with defining, observing and recording critical behaviours to target in a workplace, followed by the implementation of an intervention to change the behaviour (DePasquale & Geller, 1999). A typical feature of BBSM is the inclusion of a training program where the learning experiences are designed to produce desired cognitive or behavioural changes among participants (DePasquale & Geller, 1999). If implemented properly, BBSM can facilitate employee perceptions of personal control (DePasquale & Geller, 1999) and the self-efficacy necessary for long-term change among individuals (Bandura, 1997). Knowledge of individual and group behaviour is instrumental in understanding how safety behaviour can be influenced to change. This understanding can assist in determining if the repeating recommendations incorporated a behavioural element.

Safety Compliance

Safety behaviour can be divided into two categories: safety compliance and safety participation. Safety compliance refers to the core activities that individuals perform to maintain workplace safety, and adhere to the safety management system (i.e. wearing personal protective equipment) (Neal & Griffin, 2006). Safety participation describes behaviours that do not directly contribute to an individual's personal safety but assist in developing an environment that supports safety (i.e. attending safety meetings) (Neal & Griffin, 2006). In the past, assumptions

about how to improve safety participation and compliance in the workplace have focused interventions on compliance to regulations, blame has been attributed to poor safety attitudes, and incentive techniques have been used to change noncompliance. Researchers have since determined that identifying the antecedents and determinants of behaviour has a greater influence on compliance and participation (Neal & Griffin, 2002). Understanding the commitment to safety by all tiers of an organization, as a determinant of an organization's safety culture, assists in analyzing the repeating recommendations to see if they addressed compliance and participation.

Safety Motivation

Related to safety compliance and safety participation, is safety motivation. Safety motivation refers to an individual's willingness to exert effort to enact safety behaviours and the valence associated with those behaviours (Neal & Griffin, 2006). Therefore, some degree of authority is needed to activate the motivation to care about safety (Turner & Pidgeon, 1997). Research has demonstrated that motivation mediates the relationship between safety climate and self-reported safety compliance and participation. The relationship between safety climate and safety motivation can be explained using the social exchange theory (Blau, 1964) and expectancy-valence theory (Vroom, 1964). The social exchange theory predicts that if an individual perceives that the organization is concerned about safety, they will reciprocate through safe behaviours (Neal & Griffin, 2006). The expectancy-valence theory predicts that employees are motivated to comply with safety procedures and participate in safety activities if they believe that these behaviours will lead to valued outcomes (Zohar, 2000; Neal & Griffin, 2006). If an organization identifies safety motivation as a problem, this indicates that there may

be a broad range of underlying individual and environmental causal factors present. Therefore, safety motivation is an influential element of the overall safety culture. Understanding the social exchange theory and expectancy valence theory can assist in viewing these reports retroactively to see if perceptions reflected actions.

System Assessing and Monitoring

Monitoring and assessing the safety culture of an organization is an important factor in ensuring the effectiveness of risk management (Antonsen, 2009). Traditional measures of safety relied on retrospective, or lagging, data such as: lost-time injuries, accidents, and fatalities. In contrast, measuring safety culture is a forward-facing, predictive assessment (Flin et al., 2000; Antonsen, 2009). This shift away from lagging indicators reduces the reliance on waiting for a system to fail to identify its weaknesses.

Assessments can provide an organization with a benchmark of organizational safety performance to compare future emerging safety outcomes (Mearns & Flin, 1999). These assessments can measure various features of safety culture, including: individual and group values, perceptions, attitudes and behaviours with respect to safety, commitment of management, work pressure, competence, available resources, and visible support to safety programs. Further, a key feature of assessing and monitoring is having a safety information system that collects, analyzes and disseminates information from incidents and near misses (Flin et al., 2000; Reason, 1998). Understanding the various organizational factors that can be monitored and assessed will assist in reviewing whether the recommendations directed at these measurements focused on lagging (i.e. accidents) or leading indicators (i.e. safety culture).

2.3.4 Safety Climate

The term safety climate has been defined as the perceptions of policies, procedures, and practices relating to safety in the workplace (Neal & Griffin, 2006). It can be further defined as the manifestation of the underlying safety culture in safety-related behaviours and attitudes of individuals or groups (Mearns, Whitaker & Flin, 2003). As stated by Schein (1990) "climate [is] a reflection and manifestation of cultural assumptions."

Research has indicated that when individuals perceive a safe working environment, they will reciprocate by complying to the safety management system (Neal & Griffin, 2006; James & James, 1989). Safety climate is positively associated with safety compliance and a reduction in accidents at the individual, group and organizational levels (Brown & Holmes, 1986; Hayes et al., 1998; Hofmann & Stetzer, 1996; Rundmo, 1994; Varonen & Mattila, 2000; Zohar, 2000; Neal & Griffin, 2002). There is currently no concrete agreement regarding the key dimensions of safety climate (Neal & Griffin, 2002), and therefore there are numerous measurement tools of safety climate available that provide general, or industry specific assessments. However, the features assessed are relatively similar, including: perceptions of management attitudes and behaviours towards safety, perceived production pressures, discipline, perceptions of safety procedures, competence, individual dispositions (i.e. optimism, fatalism), self-reported safety behaviours (i.e. risk taking), and accident reporting (Flin et al., 2000). Similar to safety culture, it is important to note that perceptions of safety climate may also vary among groups within the same organization because of differences in-group processes (Neal & Griffin, 2006). Therefore, although safety culture and safety climate overlap as dimensions of an organization, they differ in fundamental elements (Neal & Griffin, 2002; Moran & Volkwein, 1992; Mearns & Flin, 1999).

2.3.5 Organizational Culture

The concept of safety culture is preceded in the literature by an extensive body of research into organizational culture (*or corporate culture*). Organizational culture is defined as a complex framework of shared behaviours, beliefs, attitudes and values regarding organizational goals, functions and procedures, which are seen to characterize particular organizations (Furnham & Gunter, 1993; Cooper, 2000; Helmreich & Merritt, 1998; Parker, Lawrie & Hudson, 2006). The complexity of the definition is reiterated by Schein (1992):

> *"Observed behavioural regularities when people interact (language, customs and traditions, rituals), group norms, espoused values, formal philosophy, rules of the game, climate, embedded skills, habits of thinking/mental models/linguistic paradigms, shared meanings and ``root'' metaphors or integrating symbols", [all] illustrate the fact that behind the term culture a lot of different meanings are hiding." (p.8)*

Research has demonstrated that within a single organization there can be both within-group homogeneity and between-group variation in perceptions (Parker, Lawrie & Hudson, 2006). This variability can be explained by exploring the sub-cultures within an organization. Antonsen (2009) pointed out that organizational cultures typically are biased to reflect the values of the dominant group, or subculture, in the organization. This is relevant to note because although organizational cultures can enhance organizational goals, they can also perpetuate negative behaviour, beliefs, attitudes, and values (Pidgeon, 1997). Therefore, to address cultures, as a form of resistance, focus must move beyond individual attitudes to shared cognitions and organizational structures. Understanding that the foundation of safety culture lies in

organizational culture is crucial for understanding the complexities of how organizational values, behaviours, beliefs, etc. are perpetuated.

In contrast to organizational culture, which incorporates values, beliefs and underlying assumptions, organizational climate is a measure reflecting the perceptions of the organizational atmosphere (Gonzalez-Roma et al., 1999). The organizational climate is therefore viewed as the property of the individual, and how they experience and interpret what happens within the organization (Bjerkan, 2010). In the literature, this is also often referred to as psychological climate. Psychological climate refers to individual perceptions of the work environment (James & James, 1989). When these perceptions are shared by members of a group or organization they are referred to as group or organizational climate (Neal & Griffin, 2006). Organizational climate measures often assess perceptions of organizational policies, procedures, and practices (Reichers & Schneider, 1990).

2.3.6 Accident Investigation and Safety Culture

Despite its origins in an accident investigation (i.e. Chernobyl 1986), it is uncommon for safety culture to be directly addressed in investigations of accidents. Strauch (2015) believes that due to limitations in the measurement of safety culture, the direct assessment of safety culture during accident investigations may produce misleading results:

> *"Investigators need to establish a cause and effect relationship in an accident, relying on identifiable performance measures, and the presence or absence of such aspects of an organization's culture, such as managerial commitment to safety, does not satisfy the need for a logical, direct link between a factor and the accident, nor is that a readily identifiable parameter." (p.106)*

However, post-accident investigations may provide the opportunity to identify more aspects of an organization's culture. In various industries, it is becoming increasingly common for companies and researchers to apply safety culture retroactively to explain accidents and incidents (Strauch, 2015). Antonsen (2009) found that the data obtained through accident investigation reports on an offshore drilling platform better described an organizations actual practices, in contrast to collecting information regarding perceived safety obtained through traditional safety culture questionnaires and assessments. Similar findings were found in an investigation of a marine accident (National Transportation Safety Board, 2013). Another investigation conducted by the Washington Metropolitan Transit Authority of a subway accident determined that the organizations actions and decisions made after the investigation, described elements of safety culture better than a direct assessment of the culture, through typical measurement methods, could have done (Stauch, 2015). Other major accidents, including: Piper Alpha, King's Cross, Clapham Junction, the Bristol Royal Infirmary pediatric cardiac exposure, and the Columbia tragedy (Reason, 1990; Warszawska & Kraslawski, 2015; Zhang et al., 2002) all discussed safety culture post-investigation.

In addition, to the debate around the inclusion of safety culture pre- or post-investigation, the discussion continues into whether safety culture should be included in the formulation of the recommendations. Very few accident investigations provide recommendations that specifically address cultural factors. However, it was found that two United States agencies, the Nuclear Regulatory Commission (2011) and the Bureau of Safety and Environmental Enforcement (2013) recognized the application of safety culture principles to increase a positive safety culture within their industry after investigations were completed. The Nuclear Regulatory Commission specifically cited safety culture principles to apply to the industry, however, the commission did

not provide insight on how to implement or monitor these factors (Stauch, 2015). Overall, what can be derived from these findings is that safety culture, although rarely directly assessed in accident investigations because of the unique difficulties in measurement and assessment, can be influential when incorporated post-investigation to distinguish between perceived safety and actual safety.

In the mining industry, various methods of disaster analysis have utilized official accident reports. Barry Turner (1978) examined a decade of mining disasters in the United Kingdom in his book Man Made Disasters. Braithwaite (1985) examined 39 coal mine disasters to focus on the role and effectiveness of enforcement in his book, To Punish or Persuade: Enforcement of Coal Mine Safety. Quinlan (2014) also examined single and multiple-fatality incidents to identify patterned causes in his book, Ten Pathways to Death and Disaster: Learning from Fatal Accidents in Mines and Other High Hazard *Workplaces.* Researchers have acknowledged that this style of sources provide "a detailed and impartial assessment of the evidence pertaining to the causes of the incident, at least within societies where there is some level of community voice, governance and due process and accountability" (Quinlan, 2014). However, it is recognized that not all accident inquiries are unbiased, including: the government, appointed investigators, the terms of reference, the legislation governing safety and the investigation process itself, time and resource constraints, and media coverage (Quinlan, 2014). Another consideration in conducting historical analysis of such reports is how investigations are shaped by the current technical knowledge, dominant discourses, and community structures during the time period. Preoccupations with certain influences can detract attention from other underlying failures. Therefore, researchers must recognize that the findings identified in an investigation report are relative to how the investigation was conducted.

2.4 BIG DATA ANALYSIS

Large bodies of data, such as OHS commissioned reports of a longitudinal data set, can be difficult to analyze. Human-based analysis of large volumes of data are time-consuming and resource-intensive to (Indulska & Recker, 2012; Smith & Humphreys, 2006), and additional challenges include coder reliability, and the influence of subjectivity and interpretation bias. Computer-assisted qualitative data analysis software (CAQDAS) can provide an alternative method, solving some of these problems.

2.4.1 Computer-Assisted Qualitative Data Analysis Software

CAQDAS can perform multiple analyses of data and provide a varied perspective on a single data set (Sotiriadou, Brouwers & Le, 2014). Typically, the mitigation of subjectivity in human coding requires an extensive investment of time and money in the content analysis process, through the investment of multiple coders and inter-coder reliability testing (Nisbett & Wilson, 1977). Coder reliability is not an issue for CAQDAS, as text segments are always coded in the same way; given the same parameter settings (Smith & Humphreys, 2006). Therefore, a primary advantage to utilizing CAQDAS is that it reduces the subjectivity and interpretation bias that may negatively affect the validity of the research (Nisbett & Wilson, 1977; Indulska & Recker, 2008). Further, CAQDAS facilitates the exploration of bodies of text (Indulska & Recker, 2012), and provides advantages related to scalability, repeatability, and consistency. There are numerous types of CAQDAS available with advantages and disadvantages of each, based on the type and size of data, and the aim of the analysis. Reviewing the types of CAQDAS provides support for the selection of Leximancer as the software best suited for scope and style of this analysis.

2.4.2 Leximancer

Leximancer is a text analytics software that performs a style of computer assisted content analysis (Cretchley et al., 2010a). Computer assisted content analysis is the semantic extraction of dominant concepts or most commonly occurring terms, based on the statistical processing of a body of text (Berelson, 1952; Weber, 1990; Indulska & Recker, 2012), followed by the relational extraction (Smith & Humphreys, 2006). The conceptual analysis examines the data for the presence, frequency, and centrality of concepts (Indulska & Recker, 2012). The relational analysis tabulates the frequency of concepts in the body of text and the co-occurrence of concepts. Co-occurrence identifies how concepts are related to each other within the documents (Indulska & Recker, 2012). The Leximancer software therefore goes beyond keyword searching, by discovering and extracting thesaurus-based concepts from the text data, with no requirement of a static dictionary (Smith & Humphreys, 2006; Weber, 1990; Indulska & Recker, 2012). The cumulative support of all the words in the thesaurus determines the classification weighting (Smith & Humphreys, 2006). The advantage of generating the concept list automatically is that the list is statistically reliable and reproducible because it is generated from the input text itself (Smith, 2003) (Appendix E).

When larger bodies of text, or datasets beyond the ability of typical analysis, are considered, Leximancer is believed to be at its greatest utility (Smith & Humphreys, 2006). Leximancer has been applied across a diverse range of big data research domains, including: evaluating accident reports in maritime operations (Grech, Horberry & Smith, 2002); comparing risk management profiles of large computer organizations (Martin & Rice, 2007); analyzing opinion polls and political commentary (McKenna, 2007); tracking changes in the content of abstracts in academic journals (Cretchley, Rooney & Gallois, 2010b); and analyzing social media

responses to controversial incidents (Pegoraro et al., 2014). To date, no studies have utilized the Leximancer software to longitudinally examine the relationship between reappearing accident recommendations and safety culture in mining.

2.4.3 Concept Mapping

In a parallel timeline to the development of CAQDAS, the field of visual text analytics has developed methods to give a visual appreciation of relationships within data-sets (Risch et al., 2008; Tufte, 2001). Concept mapping is one such technique used to display information from large bodies of text throughout the concept of space (Jackson & Trochim, 2002; Chen et al., 1996). Concept mapping can be derived algorithmically from a corpus of text (Novak & Gowan, 1984). For the latter, CAQDAS applications are used to conduct concept statistics, clustering, and multidimensional scaling analyses, which then produce the maps and analytical outputs to be interpreted (Jackson & Trochim, 2002). The automated process generates a graphic display via an interactive concept map, or as tables indicating key concepts and conceptual relationships (Angus, Rintel, & Wiles, 2013) (Appendix 2E).

When analyzing and interpreting large bodies of data, concept maps can provide additional benefits to the researcher. The concept map presents a graphical representation that illustrates relationships spatially between various concepts (Novak & Gowan, 1984; Indulska & Recker, 2012). This visualization process enables the analyst to examine concepts in the original text linked to a global perspective of the entire volume of data (Angus, Rintel, & Wiles, 2013; Smith & Humphreys, 2006). The interactive interface then allows the researcher analyze the underlying data to understand the context of the concepts, identify the sources and discussion of the concepts, and identify relevant text excerpts (Indulska & Recker, 2012). The concept

mapping feature greatly assists the interpretation in this study due to its ability to graphically represent a large body of data (Appendix E).

2.4.4 Framing Theory

Framing theory suggests that how something is presented influences the choices people make about how to process that information. The frame is defined as a mental scheme that facilitates the processing of information (Goffman, 1974), and can provide meaning to a series of events (Chong & Druckman, 2007). Frames can also be viewed as groups of various independent textual elements combined to create an overall frame. In addition to making up a frame, each independent textual element can also signal different meanings to the reader (Entman, 1993). This sociological approach to framing research includes: words, images, phrases, and presentation styles that are used to create stories (Druckman, 2001). By investigating the association between textual elements within the document and the overall framing of the story you can examine the changes in the relative proportion and stability of frames during a given time period. The framing process can make particular aspects more prominent through the selection, emphasis, and exclusion of information (Entman, 1993; Zaharopoulos, 2007) and can reflect the dominant norms and values in a society (Endres, 2004; Goffman, 1974). Therefore, framing theory proposes that an issue can be viewed from various perspectives in which people can develop a particular conceptualization of an issue or reorient their thinking (Chong & Druckman, 2007).

Tracking frames provides a process to identify trends in issues, definitions, and examine coverage across multiple sources. The application of framing theory typically requires four steps. First, the identification of an issue or an event; second, the isolation of a specific attitude;

third, the inductive identification of an initial set of frames to create a coding scheme; and finally select sources for content analysis (Chong & Druckman, 2007, p.106-108). Typically, when researchers rely on computer programs to analyze large volumes of text, they must identify the dictionary of words that mark the presence of the frame. Coders than analyze the sample identifying the presence of the predefined frames. This analysis can be carried out with the Leximancer interface, as it can identify the main themes, their underlying concepts, and their evidence words, to gain an understanding of the context of the frame (Indulska & Recker, 2012).

Framing theory can also provide insight into cultural shifts or change over time. Chong and Druckman (2007) stated that "the dimension of time allows the separation of new issues from previously discussed issues that are familiar to those who are knowledgeable on the topic." New issues are often variants of other issues that have been discussed in the past. In contrast, older issues have a defined structure and elicit more routine considerations (Chong & Druckman, 2007). Therefore, older issues can be transformed into new issues by the process of reframing. In applying the framing theory and content analysis on longitudinal data the findings can be portrayed along a timeline. This allows the discovery of cross-sectional relationships and the impact of content on industry over-time (Neuendorf, 2001). This can be referred to as conceptual drift, the change of known concepts with reference to the evidence provided by new documentation that is made available over time (Widmer & Kubat, 1996). Applying framing theory to assist in reviewing the historical component of the study will assist in reviewing the repeating recommendations to identify how older issues have been transformed into new issues.

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Chapter 3

Analysis of Recommendations from Occupational Health and Safety Mining Commissioned Reports: A 50 Year Review

ABSTRACT This research project focuses on a systematic analysis of ten Occupational Health & Safety (OHS) commissioned reports from: Canada, New Zealand, the United States, Australia, and the United Kingdom; spanning from 1967 to 2015. The objective was to identify commonalities and differences in the key recommendations across the identified reports over the 50-year timeframe. The systematic analysis was undertaken in two stages. First the text-mining software, Leximancer, was utilized to analyze the content of the recommendations through semantic extraction of dominant themes, followed by relational extraction, which involved the mapping of thematic relationships against each other. In the second stage, the researchers analyzed the themes identified in the map to fully understand the relationships and ensure proper interpretation. The thematic analysis, based on the concept map, provided a longitudinal perspective of the recommendations, identified six key themes and 49 sets of overlapping recommendations. The themes were: health and safety hazards (n=10 sets), regulating bodies (n=13 sets), emergency preparedness and mine rescue (n=9 sets), worker training (n=10 sets), the role of technology (n=4 sets), and research (n=3 sets). The results of this analysis illustrate that the same hazards continue to be identified across reports and recommendations to mitigate the identified hazard also appear in more than one report. These findings suggest that mining hazards are not being adequately addressed or that mitigation strategies are not being implemented, this is independent of time or country.

KEYWORDS OHS; Mining; Recommendations; Leximancer

3.1 INTRODUCTION

"*In 1992, a violent explosion…occurred in the depths of the Westray coal mine, instantly killing the 26 miners working there at the time"* (p.vii). *"In 2006, an explosion occurred at the Sago mine…fifty-two hours later, the bodies of 12 miners had been recovered from the mine"* (p.iii). In 2010, on Easter Monday, *"a powerful explosion tore through the Upper Big Branch mine…twenty-nine miners died"* (p.4). In 2010, the Pike River coal mine exploded, *"twenty-nine men underground died immediately, or shortly afterwards, from the blast or from the toxic atmospheres"* (p.12). Following each of these tragedies, inquiries were established, new rules and regulations were formulated and recommendations to eliminate organizational hazards were designed to prevent the reoccurrence of that particular accident (Hopkins, 2002). However, these examples illustrate four cases where the accident causation chain concluded with similar fatal methane explosions.

Mining currently accounts for 1% of the global workforce, approximately 30 million workers; but is responsible for 8% of fatal accidents at work (ILO, 2016). Fatalities, injuries, and occupational disease are still prevalent amongst miners, and places mining as one of the most hazardous occupations in the world (Stephens & Ahern, 2001). A major component increasing hazards in the mine environment is the constantly changing workplace circumstances, with the most severe changes including, but not limited to: the darkness of an environment without natural light where visibility can be reduced to zero; atmospheric air changes due to forced ventilation in the work areas, where the air components can quickly become contaminated and poisonous to the worker; and the constant threat of potentially unstable ground control, as a result of mineral extraction. Although the incidence of occupational injuries and diseases associated has declined markedly following developments in science and technology, such as

engineering controls, protective equipment, safer machinery and processes, and adherence to regulations and labour inspections (Hale & Hovden, 1998), there is a need to review and evaluate recommendations stemming from previous OHS commissioned reports in order to understand occupational accidents for miners.

3.1.1 Organizational Accidents

Reoccurring accidents are not unique to the mining industry. Aviation, aerospace, transportation, oil, healthcare, construction, among others, all have a history of accidents that have commonalities between them (Cox & Flin, 1998; Pidgeon, 1998; Zhang et al., 2002). Lessons from these accidents, for risk prevention and reduction of consequences, are drawn from the analyses of several types of single events and series of events (Dechy et al., 2012). Most of these accidents involve complex, dynamic interactions between humans, task demands, environmental events, and social and organizational factors, in the presence of weakness or gaps in the systems barriers (Clarke, 2006; Bjerkan, 2010; Dismukes, Berman & Loukopoulos, 2007). Organizational accidents are usually low-frequency events and are typically triggered by unintentional errors, made possible by pre-existing hazards that have made the system vulnerable to failure (Reason, 1990). Although the contexts of various work environments can be different, there is an opportunity to learn from occupational accident investigations and recommended practices from other countries, industries or variations within the same sector (i.e. metalliferous and coal mining) (Turner, 1978; Vuorio et al., 2013; Lind and Kivistö-Rahnasto, 2008).

3.1.2 Accident Investigations, Reports and Commissions

The outcome of an accident analysis depends not only on the investigators view on causality, but on which factors are included, and omitted, as causes and contributing factors (Lundberg, Rollenhagen & Hollnagel, 2009). Although differences may exist between how countries conduct investigations, generally government agencies or representatives conduct accident investigations (LeCoze, 2013). Dekker (2015) identified four purposes of accident investigations: (1) epistemological (i.e. establishing what happened); (2) preventive (i.e. identifying pathways to avoid future accidents); (3) moral (i.e. tracing the transgressions that were committed and reinforcing moral and regulatory boundaries); (4) and existential (i.e. finding an explanation for the suffering that occurred). The overarching intention is to avoid a reoccurrence of an accident rather than to establish blame (Vuorio et al., 2013). The evolution of accident investigation methods over time also demonstrates a shift from isolating a single immediate cause, to acknowledging multiple causes. This shift drives the elimination of active causes, without impact on reducing latent causes, and therefore does not adequately prevent future accidents (Marais, Dulac & Leveson, 2004; Leveson, 2004). For both accident causation and accident investigation, acknowledging that there is an array of accident investigation techniques available to industry is important for understanding that there are various approaches to investigate an accident, and therefore various potential outcomes. Hollnagel (2008) refers to this as the *'What-You-Look-For-Is-What-You-Find'* (WYLFIWYF) principle, which has further been elaborated to the *'What-You-Find-Is-What-You-Fix'* (WYFIWYF) principle, meaning that the causes identified in an investigation, become the foundation of the formulation of the recommendations for change (Lundberg, Rollenhagen & Hollnagel, 2009).

In the mining industry, various methods of disaster analysis have utilized official accident reports. Barry Turner (1978) examined a decade of mining disasters in the United Kingdom in his book *Man Made Disasters.* Braithwaite (1985) examined 39 coal mine disasters to focus on the role and effectiveness of enforcement in his book *To Punish or Persuade: Enforcement of Coal Mine Safety*. Hopkins (2000) conducted a sociological analysis of two Australian mining disasters which were contextually different but revealed underlying similarities. Quinlan (2014a) also examined single and multiple-fatality incidents to identify patterned causes in his book *Ten Pathways to Death and Disaster: Learning from Fatal Accidents in Mines and Other High Hazard Workplaces.* Researchers have acknowledged that these styles of sources provide "a detailed and impartial assessment of the evidence pertaining to the causes of the incident, at least within societies where there is some level of community voice, governance and due process and accountability" (Quinlan, 2014a, p.32). However, it is recognized that not all accident inquiries are free of influences that come from, for example, the government, appointed investigators, the terms of reference, the legislation governing safety and the investigation process itself, time and resource constraints, and media coverage (Quinlan, 2014a). Another consideration when conducting historical analysis of such reports, is the influence of how investigations are shaped by the current technical knowledge, dominant discourses and community structures during the time period. Preoccupations with certain influences can detract attention from other underlying failures. Therefore, the researchers must recognize that the findings identified in an investigation report are relative to how the investigation was conducted. Despite these considerations, inquiries are able to highlight and "uncover a wealth of information about how the organizations in question were operating – their cultures, incentive arrangements and organizational

weaknesses, and in addition, the way in which regulators failed to deal with any of this" (Hopkins, 2015, p.496).

3.1.3 Report Recommendations

A key part of an accident investigation, and the subsequent accident report, is the proposal of remedial actions, usually referred to as recommendations. The recommendations are established to prevent a reoccurrence of that particular accident (Hopkins, 2002; Leveson, 2001). In many cases, accident investigation recommendations focus on new rules and regulations that influence the health and safety legislation of the country, state or province in which they were published. The formulation of recommendations is therefore a reactive process, aimed to provide proactive solutions for the future (Stoop & Dekker, 2012). In many accident inquiries, the commissioners acknowledge the presence of themes identified by inquiries into previous tragedies; however, if the recommendations fall into a common set of themes that reappear, an argument can be made that the recommendations are not really achieving their purpose, or full impact.

As was discussed previously, due to the WYLFIWYF and the WYFIWYF principles, similar to how accident investigations are influenced by the accident model, the recommendations are also influenced by various factors (e.g. political and economic considerations; limitation of the number of recommendations to be published; expediency) (Lundberg, Rollenhagen & Hollnagel, 2009). The recommendations may therefore be affected by factors other than the outcome of the accident analysis. Another key issue with the formulation of recommendations and subsequent implementation is their specificity. Lundberg, Rollenhagen & Hollnagel (2009) describe this difficulty as 'problem framing' because there are

multiple levels of specificity in describing what, how or why. The recommendation process is further complicated by the translation and communication of the recommendations as intended, to all individuals that will be interpreting the document in industry to ensure that the recipient understands the problem to address.

In his book, *Ten Pathways to Death and Disaster: Learning from Fatal Accidents in Mines and other High Hazard Workplaces*, Quinlan (2014b) began the discussion by posing various questions, including the following:

> *"Why do mine disasters continue to occur in wealthy countries when major mine hazards have been known for over 200 years and subject to regulation for well over a century? What lessons can be drawn from these disasters and are mine operators, regulators and others drawing the correct conclusions from such events?" (p.1)*

These questions warrant the consideration of the recommendations that have accompanied previous accident inquires, and what insight they may offer to the cyclical nature of the repetition of similar accidents.

3.1.4 Change Management

The aim of establishing a recommendation is to create change. Traditional change management literature separates the diagnosis of a system and the intervention method (Schein, 1996). Schein (1996) states that this model has been perpetuated by industries, such as consulting, as the model proposes a diagnostic phase where an analysis is completed (i.e. interviews, questionnaires, investigations), and a set of recommendations are produced. However, the fundamental problem is that the role ends with the release of the recommendations.

The model followed in implementing change can influence an individual's perception of change, the involvement of those affected and the sequencing of change enhancing activities. There are various models of change, including Vollman's (1996) model of organizational change which consists of eight facets: (1) strategic intent (e.g., addressing the correct issues); (2) competencies (e.g., linking current competencies to a desired outcome); (3) processes (e.g., establishing metrics for assessing change); (4) resources (e.g., technology); (5) outputs (e.g., identifying expectations); (6) strategic responses (e.g., planning actions); (7) challenges (e.g., anticipating obstacles); and (8) learning capacity (e.g., identifying new required knowledge, skills and abilities).

Various industries have conducted studies of organizational change transformations. Meyer, Brooks & Goes (1990) summarized evolutionary industry- and organizational- level changes taking place in hospitals, reflecting a stable external environment. Kelly & Amburgey's (1991) conducted an analysis of the deregulation of airlines and drew conclusions on the impact of context on varying organizational responses. Haveman (1992) investigated legislative and technological changes on the California savings and loan industry. Miles & Snow's (1978) proposed that to be sustainable, change must be consistent with an organization's current identity or envisioned identity and image. Sastry's (1997) findings provide insights into how organizations may fail in attempting to introduce change, such as failure to adopt a strategic orientation that matches the requirements of its external environment.

Resistance to change efforts is directly related to how the situation is framed (Gabarro & Kotter, 1993). Therefore, there are numerous factors to consider which can influence an organizations ability to resist change. First, an organization's past experiences with strategic change have an influence on subsequent tendencies to change strategic direction (Huff, Huff &

Thomas, 1992). Second, if individuals are not prepared for the introduction of change, then denial and resistance will likely be initial consequences of a change process (Jick, 1991). Third, how change is implement is considered to be as important as what the change incorporates (Mento, Jones & Dirndorfer, 2002). Lastly, when a disconnect exists between the corporate culture and the change, culture can diminish the potency of the change initiative. Therefore, during any change process, the change must become rooted to the existing corporate culture (Galpin, 1996).

3.1.5 Big Data Analysis

Single event investigations are often criticized for their lack of statistical relevance and low cost-effectiveness (Stoop & Dekker, 2012). However, each accident investigation relies on a large body of data, from a variety of sources to reach their conclusions (Strauch, 2015). Therefore, accident investigation reports provide a great resource for conducting a large scale longitudinal review of the industry to identify lessons for risk prevention (Dechy et al., 2012).

Traditionally, large volumes of textual data were resource-intensive to manually analyze (Indulska & Recker, 2008; Smith & Humphreys, 2006), and additional challenges include coder reliability, and the influence of subjectivity and interpretation bias. Computer-assisted qualitative data analysis software (CAQDAS) can provide an alternative method, solving some of these problems. CAQDAS facilitates more effective exploration of bodies of text and provides advantages related to scalability, reliability, repeatability, and consistency; therefore, providing an analytic process that is reproducible and capable of handling large datasets that would be challenging for manual analysis (Indulska & Recker, 2008). For example, Leximancer is a text analytics software that performs computer assisted content analysis (Cretchley et al.,

2010a). Computer assisted content analysis is the semantic extraction of dominant concepts or most commonly occurring terms, based on the statistical processing of a body of text (Berelson, 1952; Weber, 1990; Indulska & Recker, 2008), followed by the relational extraction (Smith & Humphreys, 2006). The conceptual analysis examines data for the presence, frequency, and centrality of concepts (Indulska & Recker, 2008). The relational analysis tabulates the frequency of concepts in the body of text and the co-occurrence of concepts. This identifies how concepts are related to each other within the documents (Indulska & Recker, 2008).

3.1.6 Framing Theory

Framing theory suggests that how something is presented influences how that information is processed (Entman, 1993). By investigating the association between textual elements within the document and the overall framing of the story you can examine the changes in the relative proportion and stability of frames during a given time period. Tracking frames provides a process to identify trends in issues, definitions, and examine coverage across multiple sources. Framing theory can also provide insight into cultural shifts or change overtime. Chong and Druckman (2007) state that "the dimension of time allows the separation of new issues from previously discussed issues that are familiar to those who are knowledgeable on the topic" (p.108). New issues are often variants of other issues that have been discussed in the past. In contrast, older issues have a defined structure and elicit more routine considerations (Chong & Druckman, 2007). In applying the framing theory and content analysis on longitudinal data the findings can be portrayed along a timeline. This allows the discovery of cross-sectional relationships and the impact of content on industry over-time (Neuendorf, 2001). This can be referred to as conceptual drift, the change of known concepts with reference to the evidence

provided by new documentation that is made available over time (Widmer & Kubat, 1996). Applying framing theory to assist in reviewing the historical component of the commissioned mining reviews will assist in reviewing the repeating recommendations to identify how older issues have been transformed into new issues.

3.1.7 Research Objectives

Recently, the Ontario Ministry of Labour released the Mining Health, Safety and Prevention Review, a comprehensive review of underground mining (2015). Of the sixteen published recommendations, one focused on reviewing past public enquiries into mining health and safety and from Coroner's inquests into mining fatalities:

> *"Recommendation 5.4: conducting and regularly updating an aggregate analysis of all past inquests into mining fatalities; and holding information sessions with the Chief Coroner to identify opportunities for coroners to use the analysis to improve future inquests into fatalities in the mining sector." (p.12)*

This recommendation reiterates the importance of reviewing what has already been published to ensure that all possible lessons have been learned, and not forgotten, from the past. The aim of this study was to address this recommendation, by:

I) Identifying whether any recommendations are repeating in the English language, mining inquiries, over the past 50 years.

II) Determine whether there are similarities in recommendations amongst coal mining and metalliferous mining accident reports.

3.2 METHODS

The research approach follows the protocol outlined by Indulska & Recker (2008) and Cretchley, Rooney & Gallois (2010b) in their analysis of conceptual drift in journal publication history. The study was conducted in three steps. First, the selection of each commissioned report. Second, the isolation of the recommendation sections of the reports and a computer assisted qualitative data analysis. Lastly, the interpretation of the results.

3.2.1 Commissioned Report Dataset

The OHS commissioned reports were selected through a review of the literature, and in consultation with industry professionals, known for their expertise in mining safety and accident investigation (Appendix 2C & 2D). The inclusion criteria were commissioned reports from: English speaking countries, coal mining and metalliferous mining, and reports on single accidents, disasters and broader industry reviews. In addition, the report had to be deemed to have had a significant impact on OHS in the mining industry (i.e. established to investigate new and emerging issues; provide advice on an area where government lacks expertise; accesses external knowledge; identifies key issues on policy problems; provided recommendations for the future (Prasser, 2006)). The final list contained ten commissioned reports focusing on OHS, published in English, by five countries: Canada (n=5), United States (n=2), Australia (n=1), New Zealand (n=1), and the United Kingdom (n=1), were selected for analysis in this study (Table 3.1). The reports span from 1967 to 2015, and represent a combination of coal mining (60%) and metalliferous mining (40%).

Table 3.1: Description of OHS commission reports selected for this study

Commission	Date of Incident	Date Inquired	Date Published	Country	Industry	Pages
Report of the Tribunal Appointed to Inquire into the Disaster at Aberfan	October 21 1966	July 19 1966	July 19 1967	United Kingdom	Coal Mining	151
Report of the Royal Commission on the Health and Safety of Workers in Mines	N/A	September 10 1974	June 30 1976	Canada	Metalliferous Mining	380
Towards Safe Production	N/A	July 1980	April 1981	Canada	Metalliferous Mining	422
Improving Ground Stability and Mine Rescue	N/A	October 24 1984	February 1986	Canada	Metalliferous Mining	107
Report on an Accident at Moura No. 2 Underground Mine	August 7 1994	October 18 1994	April 6 1995	Australia	Coal Mining	102
The Westray Story: A Predictable Path to Disaster - Report of the Westray Mine Public Inquiry	May 9 1992	May 15 1992	November 1997	Canada	Coal Mining	831
Report on the Sago Mine Disaster	January 2 2006	January 9 2006	July 19 2006	United States	Coal Mining	124
Upper Big Branch: A Failure of Basic Coal Mine Safety Practices	April 5 2010	April 13 2010	May 2011	United States	Coal Mining	126
Royal Commission on the Pike River Coal Mine Tragedy	November 19 2010	December 14 2010	October 2012	New Zealand	Coal Mining	448
Mining Health, Safety and Prevention Review	N/A	December 2013	201March 2015	Canada	Metalliferous Mining	108

3.2.2 Computer Assisted Qualitative Data Analysis of Recommendations

A computer assisted qualitative data analysis software, Leximancer (Version 4.0, 2011, Leximancer Pty Ltd., University of Queensland), was used to explore the commissioned reports. The analysis was undertaken in two stages. First, Leximancer was used to jointly analyze the content of the recommendations within the 50-year data set, through semantic extraction of

dominant themes, followed by relational extraction. The relational extraction then provided a concept map that was used to identify and explore core themes within the recommendations, through colour coding and theme centrality indicated on the concept map (see Smith & Humphreys (2006) for further explanation of the Leximancer system).

Any documents that had separate files, such as: appendices or additional volumes, were amalgamated. Documents unreadable by Leximancer were converted verbatim into readable text files using ABBYY FineReader (Version 12, 2014, ABBYY Group, Russia). For analysis, all standard operational settings in Leximancer were set to default with the exception of: removing the identification of name-like words, turning off auto-paragraphing, and merging word variants (for detailed explanation of settings see Leximancer Manual 4.0). Word-like concepts with similar semantic meaning were merged (i.e. workers and miners), and concepts of low semantic meaning were removed (i.e. mine). To explain further, in an exploratory analysis of the recommendations (where no changes are made to the standard operational settings) the dominant theme that would emerge is 'mine.' As the reports are all from the mining industry, identifying 'mine' as a theme adds no additional support for addressing the research objective, and further, its presence may suppress a relevant theme from emerging.

3.2.3 Interpretation of Results

Based on the interpretation of the concept map, the common themes that emerge will provide the framework to analyze the recommendations. The recommendations grouped within each concept word on the map were reviewed to identify overlap, which provided insight into how Leximancer grouped the recommendations into themes, and aided the understanding of how the concepts are connected between themes. This incorporated a review of the quotes that Leximancer had collected to illustrate the concepts. In addition, the recommendations were

manually reviewed by the researchers to ensure all occurrences of repetition were captured, which further supported the interpretation of the context of the overall recommendation discussion.

3.3 RESULTS

3.3.1 OHS Commission Reports

The 10 reports span from 1967 to 2015. The reports represented a combination of coal mining (60%) and hard rock mining (40%) (Table 3.2). The average number of days from the date of an incident, to the date of the commission being inquired were 46.2 days (min: 5 days; max: 73 days), and the average duration from inquiry to publication was 552 days (min: 170 days; max: 1996 days). The reports on average were 280 pages in length, with the shortest report at 151 pages, and the longest report at 831 pages. Overall, the sample included 2,799 pages of data. Within the reports, 532 recommendations were published. On average, each report published 53.2 recommendations (min: 16 recommendations; max: 116 recommendations).

Table 3.2: Description of OHS commission reports dates of incident, inquiry, and publication, mining type and page count evaluated in this study

	1967	**1976**	**1981**	**1986**	**1995**	**1997**	**2006**	**2011**	**2012**	**2015**	**TOTAL**
Date of Incident	Oct. 21 1966				August 7 1994	May 9 1992	Jan. 2 2006	April 5 2010	Nov. 19 2010		
Date Inquired	July 19 1966	Sept. 10 1974	July 1980	Oct. 24 1984	Oct. 18 1994	May 15 1992	Jan. 9 2006	April 13 2010	Dec. 14 2010	Dec. 2013	
Date Published	July 19 1967	June 30 1976	April 1981	Februar y 1986	April 6 1995	Novemb er 1997	July 19 2006	May 2011	Oct. 2012	March 2015	
Duration	365d	659d	274d	465d	170d	1996d	191d	383d	657d	455d	**562d**
Metalliferous Mining		**X**	**X**	**X**						**X**	4
Coal Mining	**X**				**X**	**X**	**X**	**X**	**X**		6
Pages	151	380	422	107	102	831	124	126	448	108	**2799**

Note: Not all reports selected were commissioned due to a specific accident and therefore may not have a ‘date of incident.’

3.3.2 Leximancer Analysis of Recommendations

Based on the concept map (Figure 3.1), 55 ‘word-like’ concepts, and six-key recommendation themes emerged, these themes were: regulatory framework, OHS hazards, emergency management, training, technology, and research. Table 3.3 provides reference to the number of recommendations grouped within the categories, and the following subsections provide specific examples of recommendations repeating within the categories.

Table 3.3: Number of recommendations coded per theme by report year.

Theme	**Report Year**										**Total**
	1967	**1976**	**1981**	**1986**	**1995**	**1997**	**2006**	**2011**	**2012**	**2015**	
Regulatory Framework	16	30	50	16	2	23	6	13	11	4	**171**
OHS Hazards	0	72	11	4	6	31	16	6	0	4	**150**
Training	2	5	14	25	7	9	7	9	2	3	**83**
Emergency Management	0	0	2	5	8	5	37	11	3	3	**74**
Technology	1	2	0	5	0	2	7	11	0	0	**28**
Research	0	7	5	6	2	3	1	0	0	2	**26**
	19	**116**	**82**	**61**	**25**	**73**	**74**	**50**	**16**	**16**	**532**

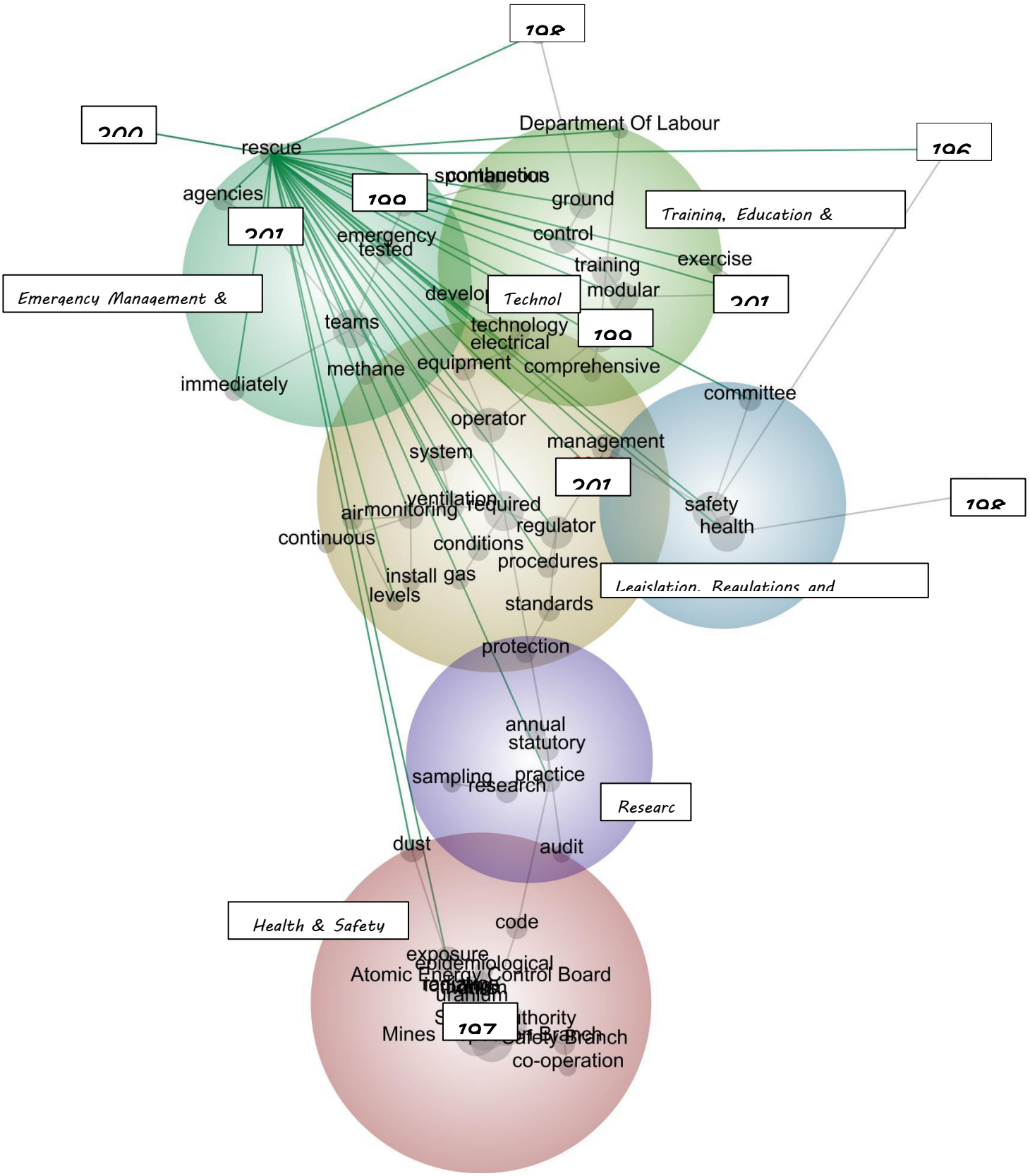

Figure 3.1: Concept map generated by Leximancer resulting in 6 major themes: regulatory framework (yellow & blue), OHS hazards (red), emergency management (green), training (light green), technology (green/yellow overlap), and research (purple).

Historical Analysis of Concept Map

In order to grasp a historical perspective, the locations of the year markers present on the map were reviewed (Figure 3.1), along with the values indicated in Table 3.3. As evident by the map, the 1976 report appears to have focused on recommendations that were different from the other reports, as noted by its distinct location at the bottom of the concept map (Figure 3.1). This is consistent with the number of recommendations identified relating to OHS hazards (n=72), being higher than found in other reports. It is also noted that the 1976-year marker is encompassed within the red cluster, indicating the most frequently used. This is consistent with the fact that the 1976 report had more recommendations than other reports (n=116).

In contrast, the 2012 Pike River report is located centrally within the yellow concept cluster which discussed legislation and governance, and was tightly linked to the term 'management' (Figure 3.1). Again, this is consistent with Table 3.3, which indicates the majority of the Pike River recommendations related to the regulatory framework (n=11). Both the 2006 Sago report and 2011 Upper Big Branch reports were located in close proximity to each other, and swayed peripherally with the discussion around emergency management and mine rescue. The Sago report had the highest number of recommendations specific to mine rescue and emergency management (n=37), and the Upper Big Branch report had the second highest frequency (n=11). The 1995 Moura report was also placed near the discussion of emergency management and mine rescue which is consistent with the Table 3.3 indicating it with the third highest number of emergency management recommendations (n=8).

The 1986 report is directly linked to the terms 'ground' and 'control' and in proximity to the discussion of training. This is consistent with the focus of the report, and the Table 3.3 which indicates that the 1986 report had the highest frequency of recommendations related to

training. The 1997 Westray report is also placed near the concept cluster focused on training. The 1967 and 1981 reports are both linked to the cluster focused on occupational health and safety, and committees, which is overlaid with the cluster focused on legislation and governance. Table 3.3 indicates that the majority of recommendations within these two reports related to regulatory frameworks (n=16, n=50). Lastly, the 2015 report is placed near training, and close to the concept of 'exercise' relating to fitness standards; however, the recommendations within the 2015 report were fairly evenly distributed between the various categories.

This analysis set the stage for identifying the overlap between themes discussed in the recommendations, specific examples of direct replication, along with identifying concepts that only occurred in distinct reports.

3.3.3 Categorization of Recommendations

Legislation, Regulations and Organizational Structure

A total of 171 recommendations were identified as being related to regulations and regulatory bodies. Of the 171 recommendations, there were 13 sets of recommendations that demonstrated repetition (Table 3.4, and Appendix 3A).

Table 3.4 Summary of recommendations related to legislation, regulations and organizational structure

Sub-Theme	**1967**	**1976**	**1981**	**1986**	**1995**	**1997**	**2006**	**2011**	**2012**	**2015**
Incentive Plans			X			X				
Hazard review		X								X
Violations							X	X		
Audits		X	X							
Enforcement			X					X		
Leg. Revisions	X	X	X		X	X	X	X	X	X
Revisions Org. Structure		X				X	X		X	
Inspections	X		X			X				
Safety Performance Data			X					X		
Mining Permits					X				X	
Communication				X		X			X	
Rights & Responsibilities			X					X		
JHSC		X	X							

The sub-theme with the most recommendations was revisions to legislation. Recommendations related to legislative changes were from all five countries, both types of mining, and were present across the full 50-year time period. For example, recommendations related to incentive plans were identified in two reports, published 16 years apart, from the same country. However, they were from different provincial jurisdictions, and one report was from hard rock mining, and one from coal mining:

> *"That the government make known its intention to legislate an end to direct individual (or small crew) production incentive plans in Ontario mines if these plans are not voluntarily discontinued." (Canada: Towards Safe Production, 1981, Page 238).*

> *"Incentive bonuses based solely on productivity have no place in a hazardous working environment such as an underground coal mine. Such schemes should be replaced, where practical, by safety..." (Canada: Westray, 1997, Page 188).*

Health and Safety Hazards

A total of 150 recommendations were identified as being related to health and safety hazards. Of the 150 recommendations, there were 10 sets of recommendations that overlapped in two or more documents (Table 3.5, and Appendix 3B).

Table 3.5 Summary of recommendations related to occupational health and safety hazards.

Sub-Theme	**1967**	**1976**	**1981**	**1986**	**1995**	**1997**	**2006**	**2011**	**2012**	**2015**
Fall protection			X	X						
Inspections			X	X						
Mine Lighting			X	X						
Ground Control			X	X		X				
Dust Standards		X				X				
Exposure Limits		X						X		X
Accident Data Base		X		X						
Ventilation Standards		X				X	X	X		
Atmosphere Monitoring					X	X				
Rock Dusting						X	X	X		

The recommendations related to fall protection were identified in two reports from the same country, and same type of mining. The recommendations were published 5 years apart, and provide an example of an initial recommendation to install equipment wherever was deemed practical, followed by the subsequent recommendation referring to making fall-on equipment installation mandatory.

> *"That wherever practical, **fall-on protection** be installed on all man-operated underground equipment." (Canada: Towards Safe Production, 1981, Page 233)*

> *"That **Fall-On Protection** shall be mandatory on all vehicles operating in areas requiring this type of protection." (Canada: Ground Control & Mine Rescue, 1986, Page 69)*

Both the 1981 report and the 1986 report also talked about inspections:

> *"That these **inspections** be carried out under an auxiliary source of high intensity lighting." (Canada: Towards Safe Production, 1981, Page 234)*

> *"That auxiliary high-intensity lighting be available in all active work areas to assist in ground-control- related activities such as **inspection** and scaling." (Canada: Ground Control & Mine Rescue, 1986, Page 64)*

Again, these recommendations were published 5 years apart, and provide an example of a repeating recommendation related to conducting underground inspections with auxiliary high-intensity light. Recommendations regarding rock dusting were only present in coal mining reports:

> *"A mine operator should file with the regulator a copy of the **stonedusting** program for the mine, including the method and frequency of testing; the type of testing equipment used; the type and number of dust-spreading machines used; the frequency of dusting; and the location and quantity of stonedust stored in the mine for emergencies (as opposed to normal usage)." (Canada: Westray, 1997, Page 350)*

> *"Adequate **rock dusting** of the area prior to sealing must be required. Operators must be required to bulk dust each entry and crosscut prior to the start of the sealing process. The final seals should not be installed until the area is inspected and the agencies are satisfied the area has been sufficiently rock dusted" (USA: Sago, 2006, Page 9)*

> *"Mechanized **rock dusting** must be conducted in all portions of underground mines, as well as the installation of "passive barriers" to help stop ignitions from turning into large explosions, such as occurred at Upper Big Branch." (USA: Upper Big Branch, 2012, Page 110)*

Rock dusting is a procedure conducted in coal mining, therefore it was not identified in any hard-rock mining reports. These recommendations came from two countries, and spanned a 14-year period. Therefore, this repetition indicates that rock dusting programs continue to be considered in accident investigations, and the formulation of recommendations.

Training, Education & Competence

A total of 83 recommendations were identified as being related to training, skills and qualifications. Of the 83 recommendations, 10 sets of recommendations were found to overlap in two or more documents (Table 3.6, and Appendix 3C).

Table 3.6 Summary of recommendations related to training, education and competence.

Sub-Theme	**1967**	**1976**	**1981**	**1986**	**1995**	**1997**	**2006**	**2011**	**2012**	**2015**
Training Engineers	X	X	X	X						
Modular Training		X	X	X			X	X		
Joint Training			X	X						X
Ground Control		X		X		X				
Rock Mechanics			X			X				
Refresher Courses				X	X	X				X
Inspector Training			X				X			
Certification			X		X	X		X	X	
Training Records						X	X			
Emergency Situations				X			X	X		

The following examples demonstrate the repetition of recommendations regarding the training and education of engineers:

> *"… in order to ensure that only suitably **qualified engineers** are employed for site investigation, a Panel of Approved Engineers should be established on lines similar to those set up under the Reservoirs (Safety Provisions) Act, 1930, as amplified in a Report on Reservoir Safety by the Institution of Civil Engineers in 1966…" (United Kingdom: Aberfan, 1967, Page 126)*

> *"That engineering schools review and redefine their responsibility to the profession to ensure that graduates are more keenly aware of and responsive to the impact of technological design upon the occupational health and safety of workers" (Canada: Royal Commission, 1976, Page 205)*

> *"That each mining company operating in Ontario employ at least one **professional engineer** with post-graduate qualification in rock mechanics and that a person holding such qualification be used in the design and planning of a mine or mine expansion and that a person holding such qualification be made responsible for the company's ground control program." (Canada: Towards Safe Production, 1981, Page 233)*

> *"That instruction in ground control be integrated into the undergraduate programs in **mining engineering**. The Rock Mechanics and Strata Control Committee of the Canadian Institute of Mining and Metallurgy shall be asked to affect this change through*

the organization of a National Forum on mining-related ground control education." (Canada: Ground Control & Mine Rescue, 1986, Page 56)

The examples provided illustrate the repetition of recommendations regarding the emergency training:

*"That the necessary additional **training in non-fire emergencies** be developed by a tripartite committee consisting of representatives of mine management, unions, and government." (Canada: Ground Control & Mine Rescue, 1986, Page 63)*

*"Training for **SCSR donning** and **escape** must be wholly separate from all other types of training miners currently receive. This training must be repeated every 90 days". (USA: Sago, 2006, Page 12)*

*"**SCSR training** should be conducted quarterly, instead of annually." (USA: Upper Big Branch, 2011, Page 113)*

*"**SCSR** and **escape training** must be done in actual conditions underground and, to the extent possible, reflect real-life emergency situations. Miners must don the SCSR training model and walk at least a portion of the escape-way." (USA: Sago, 2006, Page 12)*

*"**SCSR training** should be realistic and conducted in actual mining situations, such as riding in a man-trip and working on a longwall. It should incorporate a variety of actual in-mine scenarios for which the SCSR must be donned and activated. The training should emphasize the importance of activating the SCSR at the very first warning of an emergency." (USA: Upper Big Branch, 2011, Page 113)*

This example demonstrates repetition in recommendations of the broader concept of emergency training but also demonstrates repetitions in specific aspects of that training (i.e. frequency of training, and training in actual mining situations). These recommendations came from two different countries, and there is a distinction between the type of emergency training. In the hard rock mining environment, the recommendation relates to non-fire emergencies, and in the coal mining environment it relates to SCSR training. Within the coal mining reports that were published 5 years apart, there is distinct repetition in the recommendations relating to the frequency of the training and the training occurring in actual mining situations.

Emergency Management and Mine Rescue

A total of 74 recommendations were identified as being related to emergency management and mine rescue. Of the 74 recommendations, there were 9 sets of recommendations overlapped in two or more documents (Table 3.7, and Appendix 3D).

Table 3.7 Summary of recommendations related to emergency management and mine rescue.

Sub-Theme	**1967**	**1976**	**1981**	**1986**	**1995**	**1997**	**2006**	**2011**	**2012**	**2015**
Competitions						X	X			
Emergency Response Plans					X	X		X	X	X
Team Availability							X	X		
Roles in Emergencies			X	X			X			X
Investigation Procedures							X	X		
Rescue Team Requirements							X	X		X
Emergency Communication							X	X		
Certification										
Rescue Equipment				X		X	X	X		
Emergency Facilities				X	X		X		X	

Recommendations regarding emergency facilities were discussed in four reports, from different countries, and both metalliferous and coal mining reports, spanning a 26-year period:

*"That manway sizes, escape routes and **refuge stations** be sufficient to accommodate rescue operations." (Canada: Ground Control & Mine Rescue, 1986, Page 63)*

*"Accordingly, it is recommended that the Chief Inspector of Coal Mines set up a working party, comprising persons with appropriate knowledge and experience, to examine and report on a range of issues relating to **emergency escape facilities**." (Australia: Moura, 1995, Page 67)*

*"**Safety chambers** and **safe havens** should be required in all mining operations. The Union notes that these are two distinct systems and they cannot be used interchangeably." (USA: Sago, 2006, Page 13)*

*"To support effective emergency management, operators of underground coal mines should be required to have modern equipment and **facilities**: Operators should be required to have equipment and **facilities** suitable for self-rescue by workers during an **emergency**; Operators should be required to include, in their emergency management plans, provisions for continued monitoring of underground atmospheric conditions during an emergency; and Operators should be required to install **facilities** that will support emergency mine sealing and inertisation." (New Zealand: Pike River, 2012, Page 365)*

These examples suggest that regardless of time or geography recommendations for emergency underground facilities continue to appear in the commissioned reports. Another strong example of repetition is evident in the recommendations for emergency response plans and procedures through five similar recommendations from four countries:

> *"It is recommended that mines be required to put in place* ***Mine Safety Management Plans*** *to cater for key risk areas." (Australia: Moura, 1995, Page 62)*

> *"Every mine operator, indeed, every industrial plant or facility, should have a well-defined and comprehensive* ***emergency procedures manual****…" (Canada: Westray, 1997, Page 560)*

> *"Mine operators'* ***emergency response plans*** *(ERPs) must be treated more than just more paperwork. ERPs should be developed collaboratively with miners, their families, local responders, and mine rescue team members, and revised based on mine-specific drills and table-top exercises." (USA: Upper Big Branch, 2011, Page 112)*

> *"Emergency management in underground coal mines needs urgent attention: Operators of underground coal mines should be required by legislation to have a current and comprehensive* ***emergency management plan*** *that is audited and tested regularly; The emergency management plan should be developed in consultation with the workers and the Mines Rescue Service; The emergency management plan should specify the facilities available within the mine, such as emergency equipment, refuges and changeover stations, and emergency exits…" (Australia: Pike River, 2012, Page 354)*

*"The Ministry of Labour to require mining companies to conduct risk assessments to establish **Emergency Response Plans** for exploration sites, new mines, surface mines and mining plants." (Canada: Mining Review, 2015, Page 40)*

These four examples suggest that over this 20-year period recommendations that related to emergency response plans and procedures in mining were consistently part of commission findings.

Research

A total of 26 recommendations were identified as being related to research. Of the 26 recommendations, 3 sets of recommendations overlapped in two or more documents (Table 3.8 and Appendix 3E).

Table 3.8 Summary of recommendations related to research

Sub-Theme	**1967**	**1976**	**1981**	**1986**	**1995**	**1997**	**2006**	**2011**	**2012**	**2015**
Broad Requests			X	X						
Mine Lighting			X	X						
Communication				X			X			

Although the earlier recommendation relates to radio devices, and the latter refers to wireless communication, the following example provides an indication that despite technological advances, research into mine communications systems reappeared as a recommendation:

*"That research to perfect the development of an effective radio **communication** device for use underground be continued and accelerated, with active government support". (Canada: Ground Control & Mine Rescue, 1986, Page 58)*

> *"MSHA and NIOSH must be mandated to fund and direct continued studies and research to develop a new generation of wireless* ***communications*** *technology". (USA: Sago, 2006, Page 11)*

These recommendation examples came from two different countries, different mine environments (hard rock and coal mining), and were published 20 years apart. Another broader example is the repetition in the recommendations for mine lighting. In 1981 mine lighting research was a stand-alone recommendation, but in 1986 it was grouped into a broader request for research:

> *"That an independent authority in the field of* ***mine lighting*** *be retained to direct and co-ordinate the research effort" (Canada: Towards Safe Production, 1981, Page 234).*

> *"Among the subjects the organization shall consider for funding are the following: Rock bursts, Destressing, Backfill,…, Scaling, Pillar design and recovery,…, Ground support,…, Monitoring and testing of ground conditions,* ***Mine Lighting****, Computer modelling, and Equipment design and mechanization as it applies to hazardous ground conditions" (Canada: Ground Control & Mine Rescue, 1986, Page 51).*

These two recommendations demonstrate a shorter time period, with only 5 years between publications. Further, both of these examples came from the same country and the same type of mining environment.

Technology

A total of 28 recommendations were identified as being related to technology. Of the 28 recommendations, 4 sets of recommendations overlapped in two or more documents (Table 3.8 and Appendix 3F).

Table 3.9 Summary of recommendations related to technology

Sub-Theme	1967	1976	1981	1986	1995	1997	2006	2011	2012	2015
Changing Technology		X				X				
Tracking Devices							X	X		
Communication System	X						X	X		
Monitoring Systems				X				X		

The recommendations related to technological changes demonstrated that regardless of the different technologies available at the time, the industries response to technological advances still requires attention:

> *"That task groups set up by the Occupational Health and Safety Authority to advise on codes of practice and statutory regulations relating to* ***technological change*** *in mining include representatives of labour" (Canada: Royal Commission, 1976, Page 163).*

> *"The mine's joint occupational health and safety committee should periodically review training standards, policies, and programs to make sure that they adequately reflect* ***changing technology*** *and mining conditions and practice within the mine" (Canada: Westray, 1997, Page 133).*

These examples came from the same country; however, they represent different types of mining, and were published 21 years apart. Another example concerns **tracking devices** which were discussed in 2006 and 2011 reports:

> *"****Tracking devices*** *that can identify the location of miners at all times underground must be required at all operations. Such technology is currently available and MSHA must require mine operators to provide these devises to all miners working underground. Any*

system that can increase the ability for miners to escape a mine emergency, even if it is limited in scope, must be utilized" (USA, Sago, 2006, Page 12).

"Immediate implementation of a computerized, real-time ***electronic personnel-recording system*** *to formally identify and locate all personnel who are underground at a given time, including supervisory personnel. Redefine the state and federal regulations to ensure that no one, including management, goes underground without a tagging device." (USA, Upper Big Branch, 2011, Page 110).*

These examples illustrate the use of different terminology relating to the same concept of personnel tracking. These two reports were published within 5 years of each other, in the same country, and both from the coal mining industry. The repetition in this recommendation indicates that it may not have been implemented as the first example recommended, resulting in the restating of the importance of these systems 5 years later. Overlap in recommendations regarding **monitoring systems** were present in the 1986, and 2011 reports:

"Operators must assess the adequacy of rock dust through ***direct readout explosibility meters*** *and submit these results electronically to regulatory agencies." (Canada: Ground Control & Mine Rescue, 1986, Page 69)*

"Operators must be required to ***use real-time continuous monitoring*** *for explosive methane gas and respirable dust in coal mines." (USA: Upper Big Branch, 2011, Page 110)*

These recommendations came from two different countries, different mining types and were published 25 years apart. Although the two monitoring systems referenced in the recommendation are different, they are similar in the requirements for the operator to administer direct readout/ real-time monitoring.

3.4 DISCUSSION

The findings of this study provided an opportunity to retrospectively analyze mining commissioned report recommendations from the past 50 years. The aim of this study was to identify if there were any recommendations that were consistently reappearing in English language mining inquiries, over the past 50 years; and to determine if there were any similarities between coal mining and metalliferous mining accident report recommendations. The results of this study have captured the numerous repeating recommendations, and have provided evidence of similar recommendations between coal mining and metalliferous mining. This study further provides evidence for how centralized the overall focus has been, as all recommendations fell into 6 key themes, as captured by the visual concept map (Figure 3.1).

Legislation, Regulations and Organizational Structure

As depicted in the concept map (Figure 3.1), recommendations focusing on legislative changes and regulations were present in all commissions analyzed in the study. This is consistent with what is expected in the literature, as legislative changes offer a direct means to improve safety related outcomes: *"OHS legislation is essential as a first step for the implementation of improved measures for safety and health as well as the prevention of accidents and diseases in the world of work" (ILO, 2016).* Every commission included in the study had recommendations focused on legislation and regulations. Although legislative changes

and regulations are fundamental for improving OHS outcomes, the presence of rules or guidelines does not ensure they will be followed (Wood & Bandura, 1989). Hopkins (2002) further highlighted this issue when he argued that the issue is not whether the organization has a reporting system; it is whether, as a matter of practice, errors and near misses are reported. In essence, regardless of the recommendations to update legislation and corresponding regulations within the mining industry, if the frontline workers are not involved in a company with a positive safety culture, these recommendations could fall on deaf ears. Therefore, not only do future studies need to consider the formulation of the recommendations, but in order to address the implementation of the recommendations, to make sure they are reaching the frontline workers, additional factors such as the company's safety culture at the time of the incident, including reporting culture, need to be incorporated. Not only do we want to continue to ensure the legislation and regulations are changed and updated as necessary, but we need to also ensure the workers are receiving the new recommendations for their own safety.

Health and Safety Hazards

The primary differences identified in the recommendations between coal mining and metalliferous mining related to the type of hazards. For example, repeating ventilation concerns were evident in coal mining reports, whereas occupational diseases were more evident as repeating concerns in metalliferous mining reports (Table 3.5). However, there were some instances where hazard recommendations, from both types of mining, were focused on the same hazard, for example dust standards and mine lighting (Table 3.5). This provides further support for the sharing of knowledge across the industry and global landscape.

Emergency Management and Mine Rescue

Emergency management and mine rescue recommendations were identified in almost all reports studied. Given that the investigation process is a retrospective analysis that reviews the events leading up to an accident these findings are not unexpected. Since the rescue efforts are the final aspect of the accident, and are therefore easily inspected because they do not involve long-term recall of events or causal factors that may have occurred days, weeks, or months prior to the accident. Based on our analysis of the emergency management and mine rescue recommendations, it appears that some of the recommendations are still focusing on providing reactive responses (Table 3.7). For example, there was a selection of recommendations related to self-contained self-rescue (SCSR) devices (Appendix 3D). Although these devices can save lives if functioning correctly, they are one of the least effective means of protection based on the hierarchy of controls (Figure 2.1). Therefore, if recommendations are focusing and prioritizing these types of control mechanisms as solutions, it would seem that larger organizational malfunctions are not being addressed.

Training, Education & Competence

The findings identified recommendations related to training, education and competence in all of the reports analyzed. These recommendations covered the who (i.e. engineers, supervisors), what (i.e. ground control, emergency), where (i.e. simulated environment), when (i.e. college, refresher courses), and how (i.e. joint training, modular) the industry learns (Table 3.6). Although structured learning is critical, understanding an organization's unstructured learning, or learning culture, is also important. Learning theorists emphasize that as innovation and systems becoming more complex, organizations have an increasing need to function as a

learning culture, where learning adaptation is a continuously evolving process. Schein (1985) stated that in order to change, a shift is required in the basic assumptions that result from past learning. Assumptions are embedded and sustained by an organizations culture. In order to implement change in an organization, it must incorporate theories of organizational design and culture (Levinthal & March, 1993). Therefore, when evaluating an organization, design factors, such as: policies, procedures, compensation and organizational structure should be considered; however, documenting cultural norms, unwritten rules of work, the political system, and informal leaders may provide further benefit to achieving desired outcomes (Mento, Jones & Dirndorfer, 2002). If an organization has a strong learning culture, not only are the employees technically competent, but the organizational structure will be able to accommodate change, and identify and eliminate latent organizational issues that may challenge the system in the future.

Research & Technology

The findings of this study identified that repetition was evident related to research and technology recommendations, which continued to call for the development or adoption of new technologies or studies. The adaptation over time of recommendations related to technological advances and research, is supported by the literature on framing theory. It is known that concepts can transform over time, as new information is provided (Widmer & Kubat, 1996). However, as new issues are often variants of older issues that have been discussed in the past (Chong & Druckman, 2007), the repetition in this theme may also provide evidence for a need to improve the industries' reaction to incorporating change.

Summary of Potential Reasons Why Recommendations Repeat

In 2015, there were hundreds of traumatic fatalities in the global mining industry, including, but not limited to, the United States (n=28), Canada (n=5), the United Kingdom (n=1), Australia (n=12), and New Zealand (n=5) (MSHA, 2016; WSN, 2016; HSE UK, 2016; SafeWork AUS, 2016; WorkSafe NZ, 2016). Unfortunately, these statistics, and the findings of this study demonstrate that *"lessons learnt from past tragedies do not automatically translate into better health and safety practices for the future" (Pike River, 2012).* Despite the numerous commissions and inquiries previously established, and the resulting recommendations, similar accidents continue to occur around the world. Inquiries have the power to collect a wealth of information and provide opportunities to impact the industry in a substantial way. However, inquiries and reports are only effective if industries and governments learn from them and implement their learnings. To continue to see repetitions amongst recommendations across decades, warrants consideration for how these recommendations are formulated, implemented, and evaluated. The remainder of this section will reference sources from across the literature, including: change management, learning theories, organizational culture, and accident investigations to highlight ten potential reasons why recommendations repeat:

1. Change management is complex

Change management is a multifaceted process incorporating analytical, educational/learning, political and cultural processes (Pettigrew, 1985; Pettigrew & Whipp, 1991; Johnson, 1990; Pettigrew, Ferlie and McKee, 1992), and as a result, resistance to change can be multidimensional. If implemented poorly, change can negatively impact organizational commitment, workplace climate, morale, compliance, stress, cynicism, workplace withdrawal

(e.g., absenteeism and lateness), employee turnover, resistance, and receptivity (Mossholder et al., 1995; Gilmore, Shea & Useem, 1997; Becker, 1992; Becker et al., 1996; Meyer & Allen, 1997; Clarke et al., 1996). These negative outcomes can then become barriers for future change, and therefore should be considered in future frameworks for planning and implementing organizational change. The consequences of these barriers are evidenced in Dalziel and Schoonover's (1988) findings that organizations with patterns of resistance are likely to be repeated. Studies in other industries have found similar findings, of organization's being more likely to repeat changes they have previously experienced (Kelly & Amburgey, 1991; Meyer, Brooks & Goes, 1990). Therefore, if the recommendations are not approached with a clear change management protocol they are prone to fail, not reappear as a recommendation in a future report.

2. Feasibility

Another key aspect to consider when addressing repeating recommendations is the feasibility of the proposed change. In this case, feasibility refers to how easily or conveniently a recommendation can be implemented, and the practicality of the change. Although inquiry bodies generally engage content experts, there is the potential for a recommendation to be made that cannot be feasibly implemented. This was recently addressed in the Scottish Parliament report on the Inquiries into Fatal Accidents and Sudden Deaths Bill (2015), when it was proposed to legislate mandatory compliance to Sheriff recommendations. It was argued that to make recommendations legally enforceable would lead to numerous problems, including that recommendations may not be practicable or affordable, and may result in the inquiry becoming adversarial. This is founded on the fact that inquiries do not always cover all of the issues present, and may address individuals, or groups, not present or represented during the inquiry.

Further, there can be risks associated to the implemented change that may not have been identified or discussed prior to the recommendation being made, and could also have wider implications that need to be considered in a broader context. In the mining context, although it is not being suggested that recommendations become mandatory under legislation, some of the practical implications of feasibility discussed in Scotland are relevant to consider for why recommendations may be repeating.

3. Communication

In the change management literature, it is evident that communication is a foundational aspect of change. Mento, Jones & Dirndorfer (2002) stated that the process in which change is introduced sets the tone for recipients with respect to acceptance or rejection. For example, what was uniquely noted in the recommendation analysis, is that there were occasions where an initial recommendation 'suggested' a change, and the following report published x-years later would restate the recommendation with stronger language, such as 'regulate' or 'mandate.' For example, in 1981 it was recommended that "*that <u>wherever practical</u>, fall-on protection be installed on all man-operated underground equipment*" (Burkett et al., 1981, p.233), five years later in 1986 it was recommended that "*Fall-On Protection shall be <u>mandatory</u> on all vehicles operating in areas requiring this type of protection"* (Stevenson et al., 1986, p.69). Other terms provide leeway for interpretation, such as *"manway sizes, escape routes and refuge stations <u>be sufficient</u> to accommodate rescue operations*" (Ground Control & Mine Rescue, 1986, p.63) or "*<u>every effort should</u> be made to coordinate the emergency response of the federal, state and local agencies*" (Sago, 2006, p.14). Individuals interpretations of *sufficient*, and *every effort* may be drastically different. If a recommendation for change leaves room for interpretation errors, it may lead to organizational resistance to change.

Another key aspect of communication to consider is whom the recommendation is addressing. In 2015, the Scottish Parliament published a report on the Inquiries into Fatal Accidents and Sudden Deaths Bill. This Bill was introduced with the aim of reforming the law in relation to fatal accident inquiries (FAIs). A key issue that was addressed was the lack of implementation in the past, which was attributed to the lack of awareness of the party addressed through the recommendation. There is similar evidence of this in the recommendations examined, where ambiguity is left for who the authors were speaking to, or hoping for the recommendation to reach. In step four of Mento, Jones & Dirndorfer's (2002) change framework, it is reiterated that implementation plans should include clear responsibilities for the strategists, implementers (i.e. management, supervisors, OHS specialists on-site, government) and recipients (i.e. front line workers). Therefore, if the target audience is not aware of the recommendation, it may remain unanswered, and at risk of repeating. Another potential reason why recommendations repeat is the comprehensiveness of the recommendation. For example, if a recommendation is published that provides little support to the reader interpreting it, the reader may be less likely to attempt to uncover the meaning.

Further, researchers acknowledge that communicating the message in the same way will not have the desired affect at different hierarchical levels of the organization, and can be greatly impacted by the perceptions, and the frame of reference (FOR) that individuals have towards safety. An individual's unique FOR relates to the resistance or openness to change (Jick, 1991; Mento, Jones & Dirndorfer, 2002). Armenakis & Bedeian (1999) identified five components that should be incorporated in communicating change effectively: (1) discrepancy (i.e., we need to change); (2) self-efficacy (i.e., we have the capability to successfully change); (3) personal valence (i.e., it is in our best interest to change); (4) principal support (i.e., those affected are

behind the change); and (5) appropriateness (i.e., the desired change is right for the focal organization). Therefore, the way change is communicated needs to adapt within the organizational context (Mintzberg, 1973; Wood & Bandura, 1989). If communicated incorrectly, individuals may not trust the change, and may question if adopting the recommendation will make a difference. Using Mento, Jones & Dirndorfer's (2002) term from step 2 of his change model, the 'change recipients' represent the largest group of people that must adapt to the change, and must be convinced that the change will benefit them. Therefore, if a change initiative lacks credibility with any of the targeted audiences, or sub-cultures of an organization, "*the initiative is dead before it even begins*" (p.50). This may indicate a need to further consider how recommendations are formulated to repeat, and the specific semantic considerations for how they will be interpreted by industry, as this may.

4. Accountability & Compliance

As discussed in communication considerations, whom a recommendation addresses, can also be discussed from the perspective of accountability. Many of the recommendations do not directly identify who is being held accountable for the change being proposed. Recommendations which specifically state an organization do not leave room for questioning whom the authoring body is placing accountability on, for example:

> "*<u>MSHA</u> should rescind its regulation that permits alternative materials and methods for constructing seals, and immediately require that all seals be explosion-proof seals or bulkheads, as is required by Section 303(y)(2) and (3) of the Federal Mine Safety and Health Act of 1977*" (Sago, 2006, p.10).

In contrast, a recommendation that does not specifically state who is responsible for actioning the change, leaves rooms for individuals to assume someone else will be accountable, for example:

> *"Current communication systems must be hardened (reinforced to withstand the forces of an explosion) to increase their survivability"* (Sago, 2006, p.11).

The Scottish Inquiries into Fatal Accidents and Sudden Deaths Bill is addressing this same concern by outlining that when a Sheriff makes recommendations, the relevant person/organization, whom the recommendations are addressed, has 8-weeks to respond explaining how they will implement, or why they will not be implementing the recommendation. This therefore addresses both accountability, and feasibility as discussed earlier. Further, holding individuals/organizations accountable provides a greater ability to measure/monitor compliance.

5. Knowledge Sharing

As evidenced by the findings related to OHS hazards, there were numerous recommendations overlapping between the types of mining (Table 3.5). This provides support for highlighting the lack sharing, across the industry and global landscape, as a potential factor in repeating recommendations. For example, the Pike River (2012) report mandated a *"compar[ison] with any similar matters in other countries"* (p.7). Upper Big Branch (2010) referenced that *"lifelines were already general practice in a number of other countries"* (p.47), and Sago (2006) said "*MSHA did not require the use of tracking devices to locate trapped miners underground, even though such technology has been available for over 30 years and is used widely in other countries*" (p.IV). The recent Mining Review (2015) has again recommended the

need to share information on emerging injury and illness trends and information on incidents causing injury across the industry (recommendation 6.1), and has also recommended looking to other industries (i.e. transportation, military and healthcare) to see how mining compares in terms of worker fatigue (recommendation 1.3). If information was more readily shared between company to company, country to country, and industry to industry there would be a greater number of learning opportunities, and potentially a reduction in repetition. Flyvbjerg (2001) views accident investigations as case studies and has shown that conclusions can go beyond the individual case. This perspective further illustrates that there is an opportunity for recommendations to have benefits beyond the particular care.

6. Failure to Identify Root Cause

If a recommendation is repeating, there is also the potential that it is failing to address the root cause, and thus the same accident is occurring. Preoccupations with certain influences can detract attention from other underlying failures, which can sway the recommendations. For example, the inquiry into the Moura mine disaster (1995), a methane gas explosion killing eleven men in Australia, blamed the disaster on technical failures and management neglect. However, Hopkins (2000) studied the disaster using a different sociological approach and identified that there was a very influential culture of denial, which led to misbeliefs of vulnerability to hazards, dismissing warning signs, and the normalization of deviance, contributing to the disasters occurrence. This illustrates that the best way to "*prevent recurrence is not to focus on a discrete set of causes but to identify some background factor that, if changed, would prevent a recurrence*" (Hopkins, 2013, p.5). This has also been evident in other studies following accident inquiries, such as Vaughan's (1996) rejection of the prevalent explanations of the cause of the NASA Challenger disaster. The Presidential Commission into the disaster attributed the cause of

the accident to a technical failure of the O-ring, which seals a critical joint of the solid rocket booster. Vaughan used a sociological approach to identify deeper root causes of the failure, including the culture at NASA and the normalization of deviance. Vaughan further described that NASA's culture provided "a way of seeing that was simultaneously a way of not seeing" (1996, p.394). Researchers must recognize that the findings identified in an investigation report are influenced by how the investigation was conducted and the political and social climate of the time. Therefore, if the same preconceived causal factors are assumed to have been the primary influences, the same recommendations will be produced.

7. Prioritization of Recommendations

The number of recommendations published in the reports was highly variable, with reports ranging from 16 recommendations to 116 recommendations. Although it was beyond the scope of this study to directly address the relationship between the number of recommendations published, and how many are fully implemented, it is interesting to consider how the prioritization of recommendations and number published may be factors in repetition. If an organization is approaching the recommendations with some degree of financial, resource, or human capital limitations, the recommendations may be reprioritized by the organization. This therefore may result in recommendations not being implemented, and repeating in subsequent reports.

8. Turnover of Employees – Lessons Lost

A key aspect of an organization's ability to capture new learning is how it facilitates the dissemination of that learning to current and future employees (Marsick & Watkins, 2003). The forecasted changes with staffing in the Ontario Mining industry, provide even greater emphasis on the importance of organizational learning. It is projected that by 2018, approximately 50% of

Ontario miners will exit the industry (Mining Industry Human Resources Council, 2009) creating large hiring requirements and training needs (Mining Industry Human Resources Council, 2013), along with the wealth of organizational knowledge and history that those workers may possess. It was reported that the Ontario mining industry usually has 14,900 new workers over 10 years, however, current estimates report that the sector may require up to 59,000 new employees by 2023 (Mining Industry Human Resources Council, 2013). Turnover of employees can be associated to lost lessons. For example, four serious accidents in the UK chemical industry repeated 10 or more years later in the same company; however, not always the same unit. Kletz (1993) attributed this "*with the passage of time and changes in staff, the recommendations made after the original accidents were forgotten*" (p.4). Kletz (1993) emphasized that "*organizations have no memory; only people have memories and they move on*" (p.4). Learning theory tells us that individuals learn by their own experience, however it is unusual for the same accident to occur to the same person twice, and people are slower to learn from the experience of others. The individuals that experience an accident, or are even employed by an organization at the time of an accident, are more likely to remember it. Therefore, changes that come of the accident are more likely to be understood by those workers. However, when those workers leave, the memory of why the change occurred may dissipate with them. This can relate back to why recommendations may repeat, because similar accidents may reoccur, resulting in the same changes being suggested.

9. Act of God

As research in accident investigation and accident theory has progressed, understandings of accidents have evolved. It is now understood that disasters in large-scale technological systems are not chance events, unexpected combinations of circumstances, or an Act of God (Pidgeon,

1997; Dechy et al., 2012). Through analyzing the reports, it was noted that many of them reference the idea of accidents being an 'Act of God' and dispute it as a factor, for example:

> *"The belief that accidents are a chance event, or 'Act of God', would lead to no attempt being made to tabulate incidence, since it would serve no purpose"* (Towards Safe Production, 1981, p.60)

> *"Based on the Union's investigation, and contrary to other assertions, it is not factual to say that events beyond the control of the mine operator or the regulatory agencies simply happened. Nor is it accurate to state the explosion was "an act of God," and thus unavoidable" (Sago, 2006, p.49)*

> *"If, for example, it were determined that the explosion and deaths were the result of an "act of God" – something over which the owner had no control and could not have predicted, the company could argue that it would have no legal liability"* (Upper Big Branch, 2010, p.70).

As a reader, this leads you to believe that although the literature has shown these accidents are not 'acts of God', this may still be a conviction held by individuals in the industry. This relates to recommendation repetition, because if an individual believes the events were out of the control of mine managers, or individuals involved, they may not be as vested in supporting the recommendations.

10. Culture

Lastly, the final consideration that will be reviewed as a potential factor for repeating recommendations is the role of safety culture. The literature has recognized that OHS management systems are not effective in workplaces with a poor safety culture (Hale & Hovden, 1998). This message is still being reiterated 19 years later by Kim, Park & Park (2016), in their acknowledgement that many organizations that have introduced new OHS management strategies have failed to show improved effectiveness because these strategies did not consider the impact of the organizational culture. Kim Park & Park (2016) view safety culture as three components: psychological, behavioural, and situational. The psychological component consists of shared values, attitudes, perceptions, and beliefs that drive decisions and behaviors regarding safety. The behavioral component is defined as the methods concerning safety in the workplace, and the situational component are the policies, procedures, regulations, organizational structures, and management systems related to safety. From the perspective of these three components, and reflecting on the recommendations reviewed in this study, it is clear that the recommendations are primarily situational, with some behavioural components. This indicates that the psychological component has been vastly underrepresented in the recommendations produced in these OHS mining commissions. Other industries, and organizations, like the Health and Safety Commission, in the United Kingdom, have acknowledged that lessons learnt from previous accidents indicate that it is critical to create a corporate culture where safety is accepted as the number one priority (1993). Mento, Jones & Dirndorfer's (2002) framework outlines that change needs to be rooted in the existing culture; and if a disconnect exists between the culture and the change, culture can diminish the strength of the change initiative. Therefore, although it is clearly recognized that technological improvements, engineering controls, regulations, and

management systems reduce risks in the workplace, addressing safety culture is crucial for further risk reduction and for promoting a prevention culture (Kim, Park, Park, 2016).

3.5 LIMITATIONS & FUTURE RESEARCH

While the study encompasses 50 years, 5 countries, and 10 reports, it is not without limitations, and there are numerous avenues of future research that can stem from the findings presented. Firstly, although the sample itself was large in scope, including over 2,000 pages of data, there could have been a more diverse number of reports included. The countries included in the study were all English-speaking countries, that are considered to have good OHS standards and practices. Therefore, having incorporated additional countries that may not have as robust standards for safety may have provided a more diverse discussion.

Secondly, it is also important to acknowledge that commissioned reports, or investigation reports, have the potential to be influenced by the authoring body. Therefore, this thesis is limited to the interpretation of what was published as recommendations. It is acknowledged that there may have been discussion throughout the investigation process that further outlined recommended actions that were not captured in this data, or that were not included because of prioritization.

The breadth of the recommendations published were highly variable, with reports ranging from 16 recommendations to 116 recommendations. Although this was not a limitation of the study, as a comprehensive review was conducted utilizing Leximancer, and the researchers read all cases of repetition to verify, it identifies a unique opportunity for the future. Future studies could more specifically look at the number of recommendations published, and how many are fully implemented, to see if there is an optimal number for the industry to help prioritize future change management.

Further studies could be conducted to assess affective and behavioural reactions to organizational change within the mining industry, following substantial reviews or commissions such as those included in this study. In various industries, researchers have investigated reactions to change (i.e. Orlikowski, 1996) and have successfully identified best-practices. This could therefore be conducted for the mining industry, to assist in identifying protocols for future change management processes.

Lastly, future research could further address the recently published comprehensive Mining Review (2015) of the health, safety and prevention issues related to underground mining in Ontario. The review published 18 recommendations for the industry to focus on and address. Circling back to the research objective, this study demonstrated a methodology for conducting a historical review which addressed an array of reports simultaneously. This methodology could be specifically applied to answer recommendation 5.2 from the Mining Review (2015), which requests a method for *"aggregate analysis of all past inquests into mining fatalities…[and] to use the analysis to improve future inquests into fatalities in the mining sector."*

3.6 IMPLICATIONS & CONCLUSIONS

The finding from this study reiterate the importance of reviewing what has already been published to ensure that all possible lessons have been learned, and not forgotten, from the past. With the 2015 mining review, there is a new round of recommendations, and a new opportunity for researchers, and industry stakeholders to be reminded of what we can learn from past reports. Further, it is an opportunity to tackle the current recommendations with solutions that not only address hazards through engineering controls, regulations and legislation, but that incorporate a broader approach to ensure that the industry does not see these recommendations republished in the future. The findings of this study have additional relevance to how governments

contemplating a future public inquiry and future commissions might approach it. The findings are therefore relevant to governments, commission counsels, lawyers, researchers, and others directly involved or influenced by future public inquiries. This research has further identified a new methodology for continued research in this area, using big data analysis techniques to learn from past recommendations.

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CHAPTER 4

Analysis of Safety Culture in Occupational Health and Safety Mining Commissioned Reports: A 50 Year Review

ABSTRACT The objective of this study was to investigate how safety culture has been addressed, in ten commissioned, occupational health and safety (OHS) reports from the mining industry internationally, spanning the past 50 years. The investigation incorporated a computer assisted qualitative data analysis (CAQDAS) and the theoretical structure of framing, to review publically available English language reports. To conduct the analysis, a safety culture dictionary was developed and seeded into the CAQDAS to determine if/how safety culture has been framed, and to identify the language used to frame the concept. The analysis highlighted the use of various terms for safety culture throughout the 50-year history, with a particular emphasis on the fact that the term safety culture was not directly referenced in the selected reports until 1997. Therefore, it is evident from the findings that although safety culture was discussed, it was not a consideration in the formation of the recommendations.

KEYWORDS OHS; Mining; Safety Culture; Leximancer

4.1 INTRODUCTION

Mining currently accounts for 1% of the global workforce, approximately 30 million workers, but is responsible for 8% of fatal accidents at work (ILO, 2016). Fatalities, injuries, and occupational disease are still prevalent among miners, and places mining as one of the most hazardous occupations in the world (Stephens & Ahern, 2002). Mining broadly relates to the extraction of naturally occurring minerals by processes such as underground mining, open-cut extraction methods, quarrying, operation of wells, or evaporation pans, and dredging or recovering from ore dumps or tailings (Hamrin, 1980). A component of this hazard is because workers in the mine environment are faced with constantly changing workplace circumstances, including, but not limited to: atmospheres without natural light or ventilation, and potentially unstable ground control; as a result of mineral extraction. The International Mining Fatality database (IMFD) was created by the International Labour Organization (ILO) to establish a global record of all incidents, which caused fatalities in the last 142 years, with the majority of the data from 1980-2008 (when reporting regulations were strengthened) (MacNeill, 2008). According to the IMFD (2008), the dominant agents of fatality in mine operations include: asphyxiation, catastrophic failure, contact with moving equipment, drowning, electrocution, explosives, falls from heights, fire, gas ignited explosion, inrush, outbursts, uncontrolled release of energy and unintended operation of equipment. Due to these hazards, amongst others, the international mining industry has a long history of accidents and disasters that have resulted in high fatality and injury rates (ILO, 2016; Dechy et al., 2012). For the purpose of this study, disasters will be defined following Turner's (1978) definition of man-made disasters which distinguishes between severe accidents and disasters based on the presence of an incubation period. Turner defines the incubation period as "the accumulation of an unnoticed set of events

which are at odds with the accepted beliefs about hazards and the norms for their avoidance" (p.85). A further definition specific to the mining industry was provided by Braithwaite (1985) where a disaster is "an incident in which five or more persons lose their lives" (p.15). Therefore, although substantial progress has been made in the control of OHS hazards, with regards to exposure recognition, legislation and regulations, there are still similar accidents and disasters reoccurring.

Reoccurring accidents are not unique to the mining industry. Aviation, aerospace, transportation, oil, healthcare, construction, among others, all have a history of accidents that have commonalities strung between them. Often, this is due to a failure to learn all of the possible lessons from a single accident (Dechy et al., 2012). Most accidents involve complex dynamic interactions between humans, task demands, environmental events, and social and organizational factors, in the presence of weakness or gaps in an organizations safety system (Clarke, 2006; Bjerkan, 2010). Organizational accidents are usually low-frequency events and are typically triggered by unintentional errors, made possible by pre-existing hazards or pathogens that have made the system vulnerable to failure (Reason, 1990). Inquiries into major accidents frequently identify poor safety culture as a key contributor to the occurrence of an accident (Baker et al., 2007; Cullen, 1990; Magnus et al., 2005; Sheen, 1987; Goh, Brown & Spickett, 2010). However, it is unknown to what extent cultural influences can act as drivers for the reoccurrence of accidents. The various cultural drivers within an organization, and the fact that different individuals are involved in patterned events, implicates causal factors related to the organization. Therefore, unless cultural drivers are changed and the areas of weakness are removed, the same accidents will continue to happen (Reason, 1998).

Considering the numerous OHS reports published to date in the mining industry, and the growing recognition of the importance of addressing safety culture, there is an opportunity to learn lessons from the past, to prevent accidents in the future. This paper will incorporate computer assisted context analysis and the theoretical structure of framing to review publically available English language OHS reports from mining, to determine how safety culture has been framed in the context of causation and prevention. By retroactively reviewing accidents there is an opportunity to view pre-existing hazards, and utilize safety culture to determine how safety-related outcomes can be improved in the future.

4.2 SAFETY CULTURE

The concept of safety culture was originally constructed by the International Atomic Energy Agency's International Nuclear Safety Advisory Group (INSAG) following the Chernobyl Nuclear accident. INSAG (1986) defined safety culture as the assembly of characteristics and attitudes in organizations and individuals, which establishes that, as an overriding priority, nuclear power plant safety issues receive the attention warranted by their significance. Since the terms conception, the definition has been adapted across the literature by various industries and authors (Table 4.2). The lack of a universally accepted definition of safety culture maintains that it is a multi-faceted concept that incorporates a wide range of organizational factors. Recently, OSHA (2015) defined safety culture as the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organization's health and safety management (OSHA, 2015). Reason (1998) further simplifies the concept to be a combination of something an organization is (i.e. beliefs, attitudes, values), and something that an organization has (i.e. practices, policies, controls). The patterns of shared beliefs, attitudes

and values that a group maintains are transferred to new members as the correct way to perceive, think and feel (Hopkins, 2002), thereby propagating the prevailing culture (whether positive or negative).

A strong safety culture is associated to numerous safety-related outcomes, including: performance of safe work practices (DeJoy, Murphy & Gershon, 1995; Griffin & Neal, 2000; Mattila, Hyttinen & Rantanen, 1994), safety program effectiveness (Cheyne et al., 1998; Zohar, 1980), and reduction in accidents, near misses, and other safety incidents (Dedobbleer & Beland, 1991; Gillen et al., 2002). Research has found evidence of these positive safety-related outcomes in a range of hazardous industries (i.e. chemical and nuclear processing) (Lee, MacDonald & Coote,1993; Hofmann & Stetzer, 1996), high accident-rate sectors (i.e. manufacturing and construction) (Brown & Holmes, 1986; Zohar, 2000; Gillen et al., 2002), and in low accident-rate sectors (i.e. service industry) (Barling, Loughlin & Kelloway, 2002). In contrast, a poor safety culture can adversely undermine an organization's system of defence or protection. Breaches in defences can often stem from individuals or organizations failing to understand, and fear, the range of operational hazards present (Reason, 1998). Therefore, by developing a positive safety culture, an organization will be able to identify and mitigate latent failures before they breach defence systems, thereby improving safety related outcomes (Reason, 1998). However, if an organization fails to mitigate these failures, an accident can occur, and an investigation will be conducted.

4.2.1 Accident Investigation

Following a major accident, there are different levels of public inquiry that can be established. Types of inquiries include: Coroner's Inquests, Reviews, Commissions of Inquiry, Tribunals of Inquiry and Royal Commissions. Although differences may exist between

countries, generally government agencies or representatives conduct accident investigations (LeCoze, 2013). Dekker (2015) identified four purposes of accident investigations: (1) epistemological (i.e. establishing what happened); (2) preventive (i.e. identifying pathways to avoid future accidents); (3) moral (i.e. tracing the transgressions that were committed and reinforcing moral and regulatory boundaries); (4) and existential (i.e. finding an explanation for the suffering that occurred). The overarching intention is to avoid a reoccurrence of an accident rather than to establish blame (Vuorio et al., 2013). The evolution of accident investigation methods over time also demonstrates a shift from isolating a single immediate cause, to acknowledging multiple causes. For both accident causation and accident investigation, acknowledging that there is an array of accident investigation techniques available to industry is important for understanding that there are various approaches to investigate an accident, and therefore various potential outcomes. Hollangel (2008) refers to this as the *'What-You-Look-For-Is-What-You-Find'* (WYLFIWYF) principle, which has further been elaborated to the *'What-You-Find-Is-What-You-Fix'* (WYFIWYF) principle, meaning that the causes identified in an investigation, become the foundation of the formulation of the recommendations for change (Lundberg, Rollenhagen & Hollnagel, 2009).

In the mining industry, various methods of accident analysis have utilized official accident investigations or Coroner's Inquests to try and establish broader causation mechanisms. Turner (1978) conducted a qualitative analysis on 84 British accident inquiries spanning a 10-year period. Turner's man-made disaster model found that disasters can be defined in sociological terms; as a disruption of the existing cultural beliefs and norms about hazards, and for addressing them and their impacts. Braithwaite (1985) examined 39 coal mine disasters to focus on the role and effectiveness of enforcement. Braithwaite identified that fatal accidents are

attributable to defects in: planning, communication, definition of responsibilities, training / supervisors, and attention to hazards. He further concluded that greater compliance to law would dramatically reduce fatalities in mining. Hopkins (2000) conducted a sociological analysis of two Australian mining disasters which were contextually different but revealed underlying similarities in the presence of a culture of denial; suggesting that similar systems of belief may underlie other disasters. Lastly, Quinlan (2014) examined single and multiple-fatality incidents and identified 10-patterned causes that were consistently present in accident reports. Quinlan further discussed why patterned causes can be resistant to intervention by governments, and discussed the balance between prescriptive regulation and risk management. Researchers have therefore acknowledged that these types of sources (i.e. Inquests, Inquiries, Commissions) provide "*a detailed and impartial assessment of the evidence pertaining to the causes of the incident, at least within societies where there is some level of community voice, governance and due process and accountability*" (Quinlan, 2014, p.32).

4.2.2 Safety Culture & Accident Investigation

Despite its origin in the Chernobyl (1986) accident investigation, it is uncommon for safety culture to be directly addressed in investigations of accidents. Stauch (2012) believes that due to limitations in defining and measuring, the direct assessment of safety culture during accident investigations may produce misleading results:

> *"Investigators need to establish a cause and effect relationship in an accident, relying on identifiable performance measures, and the presence or absence of such aspects of an organization's culture…does not satisfy the need for a logical, direct link between a factor and the accident, nor is that a readily identifiable parameter." (p.106)*

However, post-accident investigations may provide the opportunity to identify more aspects of an organization's safety culture. In various industries, it is becoming increasingly common for companies and researchers to apply safety culture retroactively to explain accidents and incidents (Strauch, 2015). For example, Vaughan (1996) rejected the prevalent explanations of the cause of the NASA Challenger disaster, and used safety culture to identify the root causes of the failure. Antonsen (2009) found that accident investigation reports on an offshore drilling platform better described the organization's safety culture, in contrast to measures of perceived safety obtained through traditional assessments. Similar findings were offered in an investigation of a marine accident that identified a parallel discrepancy between employee safety beliefs and operational practices (National Transportation Safety Board, 2013). Another investigation conducted by the Washington Metropolitan Transit Authority of a subway accident determined that the organization's actions and decisions made after the investigation, described elements of safety culture better than a direct assessment of the culture through typical measurement methods (Strauch, 2015). Therefore, what can be derived from these findings is that safety culture can be influential when incorporated post-investigation to distinguish between perceived safety culture and actual safety culture. Dekker (2016) simply explained that by putting forward the question: why did their decisions make sense to them at the time? an initial picture can begin to be created of the organizations safety culture at the time of an accident.

4.2.3 Big Data Analysis & Concept Mapping

Until recently, large volumes of textual data were time-consuming and resource-intensive to manually content analyze (Indulska & Recker, 2008; Smith & Humphreys, 2006), and had additional challenges with regard to establishing inter-coder reliability, and the influence of subjectivity and interpretation bias. An alternative method to traditional human coding is

utilizing: computer-assisted qualitative data analysis software (CAQDAS). CAQDAS facilitates more effective exploration of bodies of text and provides advantages related to scalability, reliability, repeatability, and consistency; therefore, providing an analytic process that is reproducible and capable of handling large datasets that would be challenging for manual analysis (Indulska & Recker, 2008). For example, Leximancer is a text analytics software that performs a style of computer assisted content analysis (Cretchley et al., 2010). Leximancer functions in two stages, the semantic extraction of dominant concepts or most commonly occurring terms, based on the statistical processing of a body of text (Berelson, 1952; Weber, 1990; Indulska & Recker, 2012), followed by the relational extraction (Smith & Humphreys, 2006). A key advantage of Leximancer is the generation of a concept list that is statistically reliable and reproducible, as it was generated from the input text itself. In contrast, manual lists require inter-coder reliability and validity checks (Angus, Rintel & Wiles 2013). Further, Leximancer facilitates the analysis of an entire data-set, instead of a human coded subsample.

Leximancer has been used in a diverse range of research domains, including: evaluating accident reports in maritime operations (Grech, Horberry & Smith, 2002); tracking changes in research and journal foci over time (Rooney, McKenna & Barker, in press; Indulska & Recker, 2008; Cretchley, Rooney & Gallois, 2010); identifying themes and patterns in various facets of education (Grimbeek et al., 2005; Rooney, 2005); and exploring concepts related to healthcare (Davies et al, 2006; Watson & Rooney, 2010; Cretchley, Rooney & Gallois, 2010). Leximancer has also been utilized in social media analysis, combined with framing theory (Burch et al., 2015; Frederick et al., 2016). Although framing theory is typically employed to examine various forms of traditional media, and more recently social media, (e.g. Druckman 2001; Nelson & Oxley 1999; Tewksbury et al., 2000), its application in combination with computer-assisted

content analysis can provide valuable way to describe the power of a communicating text (Entman, 1993).

4.2.4 Framing Theory

In this study, the text framing process will serve to highlight various aspects of safety culture in OHS mining reports, and make them more salient through the selection, emphasis, and exclusion of information (Entman, 1993). Salience refers to making a piece of information more noticeable, meaningful, or memorable to the audience. Therefore, an increase in salience enhances the probability that receivers will perceive the information, discern meaning, process it, store it in memory, and choose to act on it (Fiske & Taylor, 1991). Thus, frames are both defined by what they include as well as what they omit.

A frame is defined as a device that reflects a pattern of cognition, interpretation, and presentation (Gitlin, 1980), and are therefore indicative of broad conceptual categories that provide culturally specific meaning to the reader (Goffman, 1974; Zaharopoulos, 2007). These cultural contexts can influence how frames are processed to reflect dominant norms and values in a society (Endres, 2004; Goffman, 1974), or in this case in an industry. Entman (1993) suggests that frames have four locations in the communication process: the communicator, the text, the receiver, and the culture. Communicators make framing judgements in deciding what to say, guided by frames that organize their belief systems. In this study, the communicator is the organization or regulatory body that produced and published the OHS report. The text contains frames defined by the presence or absence of certain keywords, phrases, sources of information, and sentences that provide thematically reinforcing clusters of facts or judgments. In this study, it is the inclusion or exclusion of safety culture related terminology. The receiver processes the frames and forms their conclusion; the receiver's interpretation may or may not reflect the

framing intention of the communicator. In this study, the receiver represents all stakeholders in the mining industry that are influenced or affected by the OHS reports. Lastly, the culture refers to the commonly presented frames that represent the mentality or commonly demonstrated thinking of a social grouping.

Further, framing theory suggests that how something is presented influences how that information is processed. Therefore, by investigating the association between textual elements within the document and the overall framing of the story, changes in the relative proportion and stability of frames during a given time period can be examined. Leximancer and framing theory can be utilized similarly to axial coding in traditional textual analysis, where themes are regrouped or reduced based on related dimensions (Saldana, 2009). These groups of stored clusters will represent the influences that guide individual processing. Gamson (1992) found that the power of a frame can be as great as the language used itself, therefore its application in this context will direct attention to how a communicated text exerts its power.

4.2.5 Research Objectives

Despite the numerous coroner's inquests, and commission reports published to date, and the resulting recommendations, similar accidents continue to reoccur around the world. This raises interest for considering how the greater organizational culture towards safety may be influencing the continuation of these similar accidents. As indicated by Stauch (2012) the direct assessment of safety culture during an accident investigation is uncommon; however, post-accident investigations may provide the opportunity to identify more aspects of an organization's culture (i.e. Vaughan, 1996; Antonsen, 2009; National Transportation Safety Board, 2013). Therefore, although safety culture may not have been directly assessed, it may be present in the

broader conversation captured in commissioned reports post-investigation, and may therefore provide insight to the nature of similar accidents. Thus, the overall objective of this study is to analyze ten OHS reports in mining to:

I) Investigate if/how safety culture has been framed; and

II) Determine if references to safety culture differ between coal and metalliferous mining.

4.3 METHODS

The method used follows a similar protocol to that used by Indulska & Recker (2008) and Cretchley, Rooney & Gallois (2010); in their analysis of conceptual drift in journal publication history, and Harpoulou's (2013) seeded analysis of organizational decision-making; in the context of business sustainability outcomes. Further, this study applies aspects of the framing theory methodology used by Burch et al. (2015) and Frederick et al. (2016). The study was conducted in four steps: (1) the selection of each commissioned report; (2) the development of a safety culture dictionary; (3) a Leximancer analysis, including contextual filtering; and finally (3) the interpretation of the results.

4.3.1 Commissioned Report Dataset

The OHS commissioned reports were selected through a review of the literature, and in consultation with industry professionals, known for their expertise in mining safety and accident investigation (Appendix 2C & 2D). The inclusion criteria were commissioned reports from: English speaking countries, coal mining and metalliferous mining, and reports on single accidents, disasters and broader industry reviews. In addition, the report had to be deemed to have had a significant impact on OHS in the mining industry (i.e. established to investigate new

and emerging issues; provide advice on an area where government lacks expertise; accesses external knowledge; identifies key issues on policy problems; provided recommendations for the future (Prasser, 2006)). The final list contained ten commissioned reports focusing on OHS, published in English, by five countries: Canada (n=5), United States (n=2), Australia (n=1), New Zealand (n=1), and the United Kingdom (n=1), were selected for analysis in this study (Table 4.1).

Table 4.1: OHS commission descriptions

Commission	Date of Incident	Date Inquired	Date Published	Country	Industry	Pages
Report of the Tribunal Appointed to Inquire into the Disaster at Aberfan	October 21 1966	July 19 1966	July 19 1967	United Kingdom	Coal Mining	151
Report of the Royal Commission on the Health and Safety of Workers in Mines	N/A	September 10 1974	June 30 1976	Canada	Metalliferous Mining	380
Towards Safe Production	N/A	July 1980	April 1981	Canada	Metalliferous Mining	422
Improving Ground Stability and Mine Rescue	N/A	October 24 1984	February 1986	Canada	Metalliferous Mining	107
Report on an Accident at Moura No. 2 Underground Mine	August 7 1994	October 18 1994	April 6 1995	Australia	Coal Mining	102
The Westray Story: A Predictable Path to Disaster - Report of the Westray Mine Public Inquiry	May 9 1992	May 15 1992	November 1997	Canada	Coal Mining	831
Report on the Sago Mine Disaster	January 2 2006	January 9 2006	July 19 2006	United States	Coal Mining	124
Upper Big Branch: A Failure of Basic Coal Mine Safety Practices	April 5 2010	April 13 2010	May 2011	United States	Coal Mining	126
Royal Commission on the Pike River Coal Mine Tragedy	November 19 2010	December 14 2010	October 2012	New Zealand	Coal Mining	448
Mining Health, Safety and Prevention Review	N/A	December 2013	201March 2015	Canada	Metalliferous Mining	108

4.3.2 Development of Safety Culture Dictionary

As the focus of this study is on the identification of safety culture, a dictionary was developed to be seeded into the Leximancer analysis. As previously discussed, there are numerous definitions of safety culture available in the literature. Therefore, throughout the background literature review on safety culture, various definitions were collected to build the Leximancer dictionary with key terminology (Table 4.2). Based on this review, 26 key terms were identified: safety culture, attitude, belief, value, morals, norms, competencies, behaviour, characteristics, social practices, perceptions, patterns, commitment, observable, shared, rituals, attributes, mental, ethical, thoughts, feelings, psychological, situational, attention, experiences, and interpretations.

Table 4.2 Definitions of safety culture

Author	**Definition**
Mearns, Whitaker & Flin, 2001	that assembly of characteristics and attitudes in organizations and individuals, which establishes that, as an overview, safety culture as a shared set of beliefs and attitudes by employees concerning the prioritization of safety issues and the maintenance of safe working conditions within the organization.
Mearns & Flin, 1999	safety culture has been described in terms of values, beliefs, attitudes, social mores, norms, rules, practices, competencies, and behavior.
Hopkins, 2002	Safety culture is the assembly of characteristics and attitudes in organizations and individuals which establishes that as an over-riding priority ... safety issues receive the attention warranted by their significance.
Reason, 1998	safety culture: as something an organization is (the beliefs, attitudes and values of its members regarding the pursuit of safety), and as something that an organization has (the structures, practices, controls and policies designed to enhance safety).
Cox & Flin, 1998	the beliefs, norms, attitudes, roles and social and technical practices concerned with minimizing the exposure of employees, managers, customers and members of the public to conditions considered dangerous or injurious.
Uttal, 1983	definition of safety culture captures most of its essentials: ‘Shared values (what is important) and beliefs (how things work) that interact with an organization’s structures and control systems to produce behavioural norms (the way we do things around here).’

Hale, 2000	safety culture, on the other hand, refers to 'the attitudes, beliefs, and perceptions shared by natural groups as defining norms and values, which determine how they react in relation to risks and risk control systems.'
Fernández-Muñiz, Montes-Peón & Vàzquez-Ordás, 2007	A set of values, perceptions, attitudes and patterns of behavior with regard to safety shared by members of the organization; as well as a set of policies, practices and procedures relating to the reduction of employees' exposure to occupational risks, implemented at every level of the organization, and reflecting a high level of concern and commitment to the prevention of accidents and illnesses.
Pidgeon, 1997	Sometimes culture is discussed in terms of observable behaviours (`the way we do things around here') and sometimes more as a system of symbols or meanings (for example, as a shared cognitive model, or as the assemblage of stories, arguments, myths, rituals and symbols that permeate organizational life). Note that the two approaches are to some extent interdependent, in that meaning often both constructs the `object' of inquiry and is in turn constructed itself through observable behaviour and material life.
Turner, Pidgeon, Blockley, & Toft, 1989	The set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimizing the exposure of employees, managers, customers, and members of the public to conditions considered dangerous or injurious.
International Nuclear Safety Advisory Group, 1986	Safety culture is that assembly of characteristics and attitudes in organizations and individuals, which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance.
Advisory Committee for Safety in Nuclear Installations (ACSNI), 1993	The product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine commitment to, and the style and proficiency of, an organization's health and safety management.
Zohar, 1980	A summary of molar perceptions that employees share about their work environments.
Glennon, 1982	Employees' perceptions of the many characteristics of their organization that have a direct impact upon their behaviour to reduce or eliminate danger (safety climate) and, safety climate is a special kind of organizational climate.
Brown & Holmes, 1986	A set of perceptions or beliefs held by an individual and/or group about a particular entity.
Cox & Cox, 1991	Safety cultures reflect the attitudes, beliefs, perceptions, and values that employees share in relation to safety.

Dedobbeleer & Bealand, 1991	Molar perceptions people have of their work settings.
Pidgeon,1991	The set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimizing the exposure of employees, managers, customers and members of the public to conditions considered dangerous or injurious.
Ostrom, Wilhelmsen & Kaplan, 1993	The concept that the organization's beliefs and attitudes, manifested in actions, policies, and procedures, affect its safety performance.
Cooper et al., 1996	Safety climate is concerned with the shared perceptions and beliefs that workers hold regarding safety in their work place.
Geller, 1994	In a total safety culture (TSC), everyone feels responsible for safety and pursues it on a daily basis.
Niskanen, 1994	Safety climate refers to a set of attributes that can be perceived about particular work organizations and which may be induced by the policies and practices that those organizations impose upon their workers and supervisors.
Coyle, Sleeman & Adams, 1995	The objective measurement of attitudes and perceptions toward occupational health and safety issues.
Berends, 1996	The collective mental programming towards safety of a group of organization members.
Lee, 1998	The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, and organization's health and safety management.
Cabrera & Isla, 1998	The shared perceptions of organizational members about their work environment and, more precisely, about their organizational safety policies.
Williamson et al. 1997	Safety climate is a summary concept describing the safety ethic in an organization or workplace which is reflected in employees' beliefs about safety.
Kennedy & Kirwan, 1998	An abstract concept, which is underpinned by the amalgamation of individual and group perceptions, thought processes, feelings and behaviours, which in turn gives rise to the particular way of doing things in the organization. It is a sub-element of the overall organizational culture.
Glendon & Stanton, 2000	Comprises: attitudes, behaviors, norms and values, personal responsibilities as well as human resources features such as training and development.
Guldenmund, 2000	Those aspects of the organizational culture, which will impact on attitudes and behavior related to increasing or decreasing risk.

Cooper, 2000	Culture is 'the product of multiple, goal-directed interactions between people (psychological), jobs (behavioral) and the organization (situational); while safety culture is 'that observable degree of effort by which all organizational members directs their attention and actions toward improving safety on a daily basis.'
Mohamed, 2003	A sub-facet of organizational culture, which affects workers' attitudes and behavior in relation to an organization's on-going safety performance.
Richter & Koch, 2004	Shared and learned meanings, experiences and interpretations of work and safety - expressed partially symbolically – which guide people's actions towards risk, accidents and prevention.
Fang et al. 2006	A set of prevailing indicators, beliefs and values that the organization owns in safety.

4.3.3 Leximancer Analysis, Context Filtering & Interpretation

Leximancer (Version 4.0, 2011, Leximancer Pty Ltd., University of Queensland) was used to analyze the commissioned reports. Any documents that had separate files, such as: appendices or additional volumes, were amalgamated. Documents unreadable by Leximancer were converted verbatim into readable text files using ABBYY FineReader (Version 12, 2014, ABBYY Group, Russia). For analysis, all standard operational settings in Leximancer were set to default with the exception of: removing the identification of name-like words, turning off auto-paragraphing, and merging word variants (for detailed explanation of settings see Leximancer Manual 4.0). Further, word-like concepts with similar semantic meaning were merged (i.e. workers and miners), and concepts of low semantic meaning were removed (i.e. mine). The previously selected terms, to define safety culture, were then seeded into the Leximancer dictionary. After the initial analysis, each concept was filtered according to Yin (2009) to clarify the concepts accurately reflect the meaning of the retrieved words.

This analysis provided a concept map that represented the 50-year data set, and assisted in the identification and exploration of safety culture within the data. Drilling down to the seeded terminology facilitated the identification of the underlying concepts, and their relative distance to

understand connectivity, which supports the interpretation of the context of which safety culture appears in the reports.

4.4 RESULTS

Of the 26 key terms originally seeded into the Leximancer thesaurus, 24 were identified in the data. Through the iterative process, Leximancer identified additional supporting words in the thesaurus, resulting in a total of 8,279 references on safety culture, being identified in the text set. However, after filtering the text it was determined that 7,315 references could not be justified for inclusion. Yin (2009) refers to filtering as the process of: removing synonyms that the software did not identify in the text; removing concepts where the accumulated evidence (i.e. text excerpts) did not justify inclusion in the discussion; and removing words that are used in a different context. Therefore, 964 references were included in the analysis. For example, the text excerpts regarding behaviour related to both human behaviour and the behaviour of the underground environment (e.g. “soil mechanics has been defined as the scientific study of the behaviour of an aggregation of discrete particles” (Aberfan, 1967, p.129)). Therefore, only human behaviour text references were utilized in the analysis, and additional references were removed.

The analysis identified six themes: safety culture, attitude, competence, belief, patterns, and norms, in descending order of dominance. Within the themes, terms that are semantically related are visualized within the same cluster (bubble). For example, within the theme attitude, the terms: behaviour, feelings, thoughts, characteristics, perceptions, and psychological were all grouped (Figure 4.1). This indicates that those terms were used in semantically similar contexts. From the seeded terms in each cluster (bubble), the underlying text references were then used to

understand the context behind each seeded term to ensure contextual relevance (Yin, 2009; Harpoulous, 2013).

Once the themes were identified, the researchers reduced them into two frames according to whether or not they related directly to the (a) The Individual, and (b) The Organization. The frames and their sub-themes (i.e. mini frames (Altheide, 1996, p. 30) are described below using textual examples.

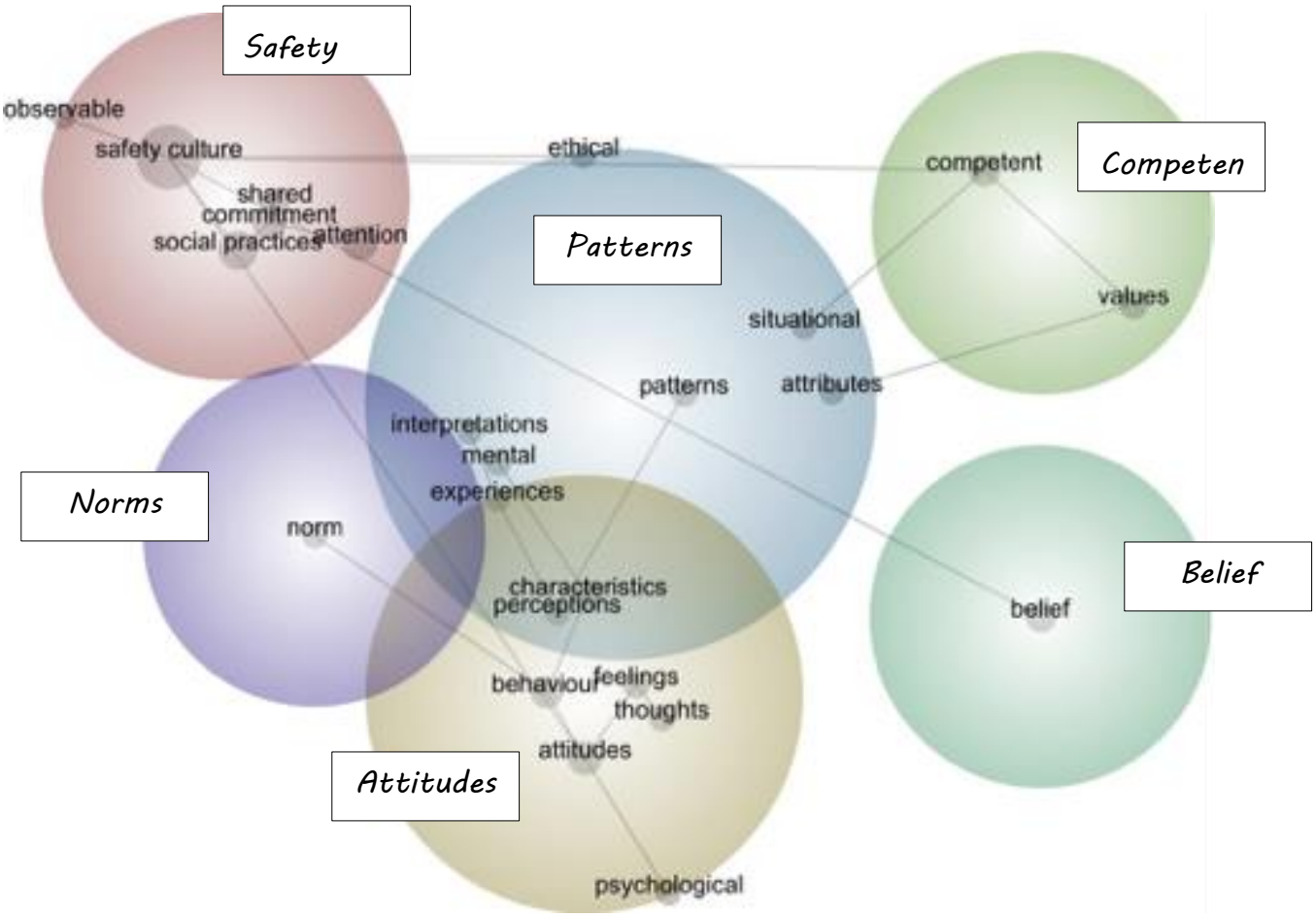

Figure 4.1: Concept map of seeded safety culture terms used to develop the frames: Frame 1 – The Individual: attitude (yellow), competence (light green), patterns (blue), and norms (purple); Frame 2 – The Organization: belief (green), and safety culture (red).

4.4.1 Frame 1: The Individual

The Individual frame was comprised of four themes (or mini-frames): *attitude*, *competence, patterns* and *norms*.

Attitude

The attitude theme contained various descriptors including: attitude (n=162), behaviour (n=118), characteristics (n=46), feelings (n=20), perceptions (n=19), thoughts (n=13), and psychological (n=4). The *n* values represent the number of times each term appeared, after context filtering (Yin, 2009).

Attitude: The discussion surrounding attitude was very broad, incorporating theories on how to shape attitudes, how to define and measure attitude, the presence of attitudinal sub-units within organizations, and the various factors which influence a worker's attitude towards safety. The literature presented in Towards Safe Production (1981) identified that although there are various definitions of attitude, "an attitude is always directed toward some object" (vol.2, p.48); in this discussion, the object is safety. Weaved throughout many of the attitude references was the underlying influence of management's attitudes in shaping the manner in how a workplace functions (Westray, 1997). There was also mention of 'dangerous attitudes' that relate to risk-taking behaviours, for example: "*it suggests a profoundly dangerous attitude that fire bossing a mine is just another burden imposed by MSHA and the WVMHST. A section foreman's failure to perform them diligently and honestly reflects poorly on the attitudes up the company's chain of command*" (Upper Big Branch, 2011, p.98). Overall, the discussion urged the need for attitudinal changes to avoid future tragedies.

Behaviour: Similar to attitude, the term behaviour was incorporated into a broad range of references related to the individual worker, as it relates to unsafe behaviours, risk taking, and accidents. A repeating reference was the concept of the propagation of unsafe and reckless behaviour, as illustrated in Westray (1997) the "*mindset requires supervisory behaviour to counteract the nonchalant attitude often encountered in more experienced workers, who may have adopted hazardous shortcuts and a dangerously complacent approach to occupational risks*" (p.94). The discussion also provided insight into the factors contributing to risk taking behaviour "*the picture that emerges from the testimony is one of a workforce taking great risks of workplace accidents as the result of three major factors acting in conjunction: the behaviour of management, the general economic conditions in the area, and the motivations of the miners themselves. Management was perceived by workers as focused on production at the expense of safety"* (Westray, 1997, p.186). There was also evidence captured in the analysis that demonstrated explicit causes of unsafe behaviour, for example "*the joint investigation revealed many reports of underground workers at Pike bypassing machine-mounted sensors by various means*" (Pike River, 2012, vol.2, p.141). Lastly, there was a consistent emphasis on how influential behaviour can be for survival *"there are few industries in which one's safety, indeed one's very survival, is so inextricably linked to the attitudes, practices, concerns, and behaviour of fellow workers. Truly, in the underground coal mining environment, you are your brother's keeper"* (Westray, 1997, p.vii.). Overall, the discussion demonstrated the emphasis on individual's behaviours captured as safe or unsafe acts.

Characteristics: The term characteristics was used in relation to the "*notion of the individual* [as it] *captures the characteristics that influence human behaviour, such as competence, experience, attitude and personality. Some of these are fixed; others are adaptable"* (Pike River, 2012, vol.2,

p.28). Characteristics were also incorporated into the accident causation discussion as they are a consideration within human factors, where *"human factors are the environmental, organisational and job factors, and human and individual characteristics, which influence behaviour at work in a way which can affect health and safety"* (Pike River, 2012, vol.2, p.27). Lastly, the term characteristics was found within the discussion on compliance strategies, where it was discussed that "the extent to which employers do not comply with their health and safety obligations, the characteristics of those employers, the drivers of non-compliance and the remedial action required" (Pike River, 2012, vol.2, p.30) is a primary area of interest. This in turn impacts the intervention strategy an organization selects, such as: changes to regulations, codes of practice, and enforcement.

Feelings: The term feelings was expressed in references from the literature or as concerns expressed from individuals. For example, the literature presented in Towards Safe Production (1981) discussed how *"attitudes only exist as a function of some object which is cognitively assessed, which elicits emotions and feelings, and which may generate behaviour" (*vol.2, p.48). References specific to individuals broadened the discussion to incorporate terms such as 'distrust' as evident in the Westray (1997) report: "*Wayne Cheverie expressed similar concerns and feelings of distrust vis -àvis Westray management: Some of the people who were appointed to the safety committee I felt I couldn't trust not to expose any concerns that I had about safety back to management, and therefore making me vulnerable to the tactics of management as far as intimidation and harassment*" (p.180). Other terms, such as emotions were captured with this term, and related to stress-related anxiety stemming from mine rescue recovery efforts (Mining Review, 2015).

Perceptions: Perceptions was predominantly discussed in three forms: how perceptions are formed, the influence of perceptions on roles and expectations, and how perceptions can influence accidents. Towards Safe Production (1981) provided the explanation that the "*factors influencing…expectations are a combination of a range of highly complicated sources such as the economic conditions, management philosophy and attitudes, legislative requirements, other organizational issues, etc."* (vol.2, p.78). The ways in which these perceptions manifest themselves transitioned the discussion to the influence of perceptions on roles and expectations. For example, it was discussed how frequently individuals have perceptions of the roles of others (i.e. supervisors perceive the role of management) which often leads to conflict and ambiguity when outcomes vary from the expected (Towards Safe Production, 1981). Role ambiguity was further discussed to explain how expectations of another individual's role is based on what is perceived to be important by the individual forming the perception. A further illustration of how perceptions differ between individuals and can impact an accident was found in the Moura report (1995), "*the Inquiry concluded that these reports may well have been coloured by differing individual perceptions, the passage of time and the merging of pre- and post-event knowledge*" (p.37).

Thoughts: The references for the term thoughts captured a broad discussion related to the literature available on cognitive dissonance theories and emotions. For example, "*a readiness to assess or evaluate an object in a certain way; it is the intellectual part of an attitude and encompasses the thoughts of an individual*" (Towards Safe Production, 1981, vol.2, p.48).

Psychological: Similar to the term thoughts, the term psychological was primarily referenced in relation to the literature on psychological theories, with no references directly linked to

investigative findings. However, the literature directly related to how "*a person's actions are motivated in one way or another, consciously or unconsciously, and that no behaviour is totally devoid of some underlying psychological mechanism"* and how "*attitudes are psychological traits*" (Towards Safe Production, 1981, p.51). This discussion helps understand how accidents, originating from unsafe acts, can be viewed as a motivated behaviour, and as such can be identified related to accidents.

Competence

The competence theme contained two descriptors including: competence (n=119), and values (n=8).

Competence: The discussion around competence was multi-directional relating to the overall knowledge and skills of various individuals, including members of Ministerial and supporting agencies, researchers, workers, supervisors and management. For example, the competence of engineers was frequently discussed as causal factors relating to the accident: *"Amounted to a frank recognition of the fact that in April 1965—18 months before the disaster—there existed on Merthyr Mountain a situation which, had it been examined by a competent civil engineer, must have led to proper investigation" (Aberfan, 1967, p.76).* The commissions also focused on the need for individuals in the mining environment to be technically competent and risk aware: "*With respect to training and skills development, all agree that all workers on a job-site need to be: trained and competent in the skills they need to perform their tasks, including the use of any equipment they are provided or required to use aware of the hazards and associated risks they may encounter in their work"* (Mining Review, 2015, p.41). The discussion surrounding competence also included references to the failure of the system's ability to identify the lack of

competence in individuals: "*The traditional testing of candidates for certification as competent coal miners degenerated to a perfunctory formality, revealing nothing of the candidates' lack of training or experience*." "*It seems almost axiomatic that an underground coal mine should retain the services of competent management and engineering personnel with proven experience and technical competence. Westray was significantly lacking in this regard."* (Westray, 1997, p.380). Further, there was lengthy discussion on how individuals receive their training, qualifications, and certifications: "*the regulatory system should drive training programmes that produce a qualified and competent workforce which is aware of the major risks in underground coal mining and how to manage them. Deficiencies and gaps in the regulations are holding back the development of the workforce*" (Pike River, 2012, vol.2, p.338).

Values: Values was used in the discussion of both personal values, and the perceived value attributed to OHS. To describe the mindset of individuals in the workplace it was commonly used amongst other terms, such as: norms, beliefs, and attitudes (Pike River, 2012; Towards Safe Production, 1981; Ground Stability 1986). Whereas in relation to the perceived value, it was indicated that management influences the value placed on safety by establishing an environment where workers can raise OHS concerns (Westray, 1997; Pike River, 2012).

Patterns

The patterns theme contained various descriptors, including: patterns (n=12), mental (n=7), experiences (n=7), ethical (n=6), situation (n=4), interpretations (n=4), and attributes (n=1).

Patterns: The references related to patterns primarily focused on inspection patterns, human behaviour patterns, and reoccurring patterns in accident causation, for example: "*the information I have seen shows me recurring patterns of causal factors that I know are well established in the*

literature to increase the likelihood of a process safety event" (Pike River, 2012, vol.2, p.76).

Mental: The discussions using the term mental were strongly related to how role conflicts and role ambiguity can affect the mental well-being of an individual worker (Towards Safe Production, 1981).

Experiences: Experiences were discussed because of their influence on the attitudes and behaviours of an individual: "*factors such as personal background, skills and abilities, and past experiences would play an important part in this process... a person's experiences form the backbone of his attitudes*" (Towards Safe Production, 1981, p.64). It was also discussed in relation to how various factors (i.e. communication, attitude, group norms, etc.) can influence an individual's ability to prepare for future experiences.

Ethical: The discussion around ethics was both implicit and explicit. Implicitly the discussion covered a range of assurances that the companies had implied and if acting ethically, would have complied too. There were few explicit ethics references; however, those identified related primarily to the ethical dilemmas faced by medical supervisors (Royal Commission, 1976), and literature on self-reliance as it relates to striving for ethical compliance (Westray, 1997).

Situation: The limited references referring to situation (or situational) related to how complex and interrelated attitudes, job behaviour, and accident circumstances are based on their situational nature, therefore making their measurement difficult (Towards Safe Production, 1981). There was also a singular reference related to the need for a "*keen sense of situational awareness*" from mobile equipment operators to minimize the risk of mobile equipment collisions (Mining Review, 2015, p.27).

Interpretations: The references related to interpretations reflected how "*the individual himself, by his own perceptions, expectations, and interpretations [determines] how he ought to behave. This refers to a synthesis of personalized representations of the requirements within the organization, some of which may be acquired as a consequence of direct experiences and others may develop as a result of indirect influences"* (Towards Safe Production, 1981, p.64). There were also minimal references related to interpretations of the responsibilities encompassed under certain positions.

Norms

The norms theme contained only one descriptor: norms (n=5).

Norms: The references referred to the normalization of deviance, and reliance on unsafe work practices. For example, it was referenced in Upper Big Branch (2011) that *"the not-so-subtle message to employees [was] that MSHA [was] costing the company money – and workers shouldn't aid in that process. In an organization where deviance is not the norm, the same information might be used to deliver a very different message, 'We have some very serious safety problems at this mine, so much so that we've racked up a million dollars in penalties'"* (p.101). This example of the reinforcement of deviant practices illustrates how a negative safety culture can be perpetuated through an organization, and ultimately can contribute to an accident occurring.

4.4.2 Frame 2: The Organization

The Organization frame, was comprised of two themes (or mini-frames): *safety culture* and *belief.*

Safety Culture

The safety culture theme contained various descriptors, including: commitment (n=95),

social practices (n=83), attention (n=68), safety culture (n=53), shared (n=20), and observable. References within this theme broadened the discussion beyond the individual, to the larger organizational practices.

Commitment: The references about commitment not only focused on the need for a commitment to OHS from all stakeholders (i.e. workers, supervisors, management, unions), but prompted the industry to broaden the view beyond the behaviour of individuals "*A genuine commitment to safety means not just examining miners' work practices and behaviors. It means evaluating management decisions up the chain of command – all the way to the boardroom – about how miners' work is organized and performed"* (Upper Big Branch, 2011, p.4). The discussion also encompassed the forms in which commitments can be expressed within an organization, such as, *"a policy statement confirming the organization's commitment to safety and the obligation upon workers, supervisors and management to contribute to a safe working environment" (Towards Safe Production, p.24).* Lastly, commitment was also used in relation to how a OHS system can be challenged, for example: *"Miners' rights to a safe workplace are compromised when the operator's commitment to production comes at the cost of safety"* (Upper Big Branch, 2011, p.112).

Social Practices: The discussion around social practices largely encompassed the lack of group dynamics that support health and safety in the workplace, and the need for establishing such social practices: *"industrial disease and injury is not settled simply by setting environmental standards. It is determined by individual, legislative, and social judgments as expressed in work practices and their supervision, in regulatory standards and processes of enforcement"* (Report of the Royal Commission, 1976, p.95). Frequently, the references of social practices were

accompanied with references to safety ethics and safe practices, and discussed how the poor practices *penetrated every facet of the operation on a daily basis* (Westray Report, 1997, p.188*).* The majority of these references further indicated a failure on the part of management to be a leader in safe practices, and instead management more often "*trivialized safety issues that filtered down through the workforce*: *The absence of a safety ethic at Westray manifested itself through every facet of the operation - the hazardous dust, gas, and roof conditions, the multitude of illegal practices, the ineffective environmental monitoring system, the lack of proper safety equipment for miners, the state of housekeeping in the mine, and the human relations issues such as management- worker relations and the ineffectiveness of the joint occupational health and safety committee"* (Westray Report, 1997, p.137). Further, the text provided evidence of the disconnect between safety standards and the actual practices within the mine: "*There is an obvious disconnect between the lofty safety standards extolled by Blankenship and the reality of conditions inspectors and investigators found in the Upper Big Branch mine* (p.95)*…Most objective observers would find it unacceptable for workers to slog through neck-deep water or be subjected to constant tinkering with the ventilation system – their very lifeline in an underground mine. Practices such as these can only exist in a workplace where the deviant has become normal, and evidence suggests that a great number of deviant practices became normalized at the Upper Big Branch mine"* (Upper Big Branch, 2011, p.97). Overall, this component of the theme demonstrates how pervasive social practices can be within an organization, and how great the disconnect between standards and practices is.

Attention: Attention was predominantly discussed in three forms: the diversion of attention, drawing attention, and communicating the need for attention. The diversion of attention was evidenced through competing priorities (i.e. ground control, production pushes) of the

organization, resulting in the diversion away from safety concerns. For example, "*The response of Westray management to these continuing problems seemed to exacerbate them and divert attention from other serious safety concerns. In the result, the entire safety mentality at Westray deteriorated while management was consumed with its apparent inability to deal with ground control…Although it is impossible to quantify the contribution of such a major diversion to the disaster, it was likely significant"* (Westray, 1997, p.382). The diversion of attention resulted in many of the workers in these mines to be exposed to risks that could have been properly managed. Drawing attention was related to the importance of conducting risk assessments to draw industry attention to specific hazards: "*Regular risk assessments help focus attention on the hazards that pose the greatest risk to health and safety. They also ensure that the sector is able to identify new or evolving hazards and take steps to mitigate them"* (Mining Review, 2015, p.6). Lastly, the commissions provided evidence of OHS concerns failing to be disseminated throughout the organizations. These failures were both top-down, and bottom-up, as upper management's lack of attention resulted in failing to make workers aware of present risks, and subsequently the organizational design challenged a worker's ability to bring forward issues, resulting in "*many high-potential incidents [not being] reported to the board*" (Pike River, 2012, vol.2, p.55). This component of the theme illustrated that if safety is not prioritized and allocated the attention it warrants the organization fails to protect its workers.

Shared: References of sharing related to community concerns, governance responsibilities, and knowledge translation and exchange. There was evidence of concerns that were widespread and shared by workers and members of local communities about the hazards present in the mines (Aberfan, 1967). The shared responsibilities of governing bodies were also frequently referenced, particularly the role of management: "*Although the overall responsibility for safety in*

the workplace lies with the top management and although this responsibility cannot be shared, cooperation of everybody in the workplace is essential for the effective discharge of that responsibility" (Towards Safe Production, 1981, p.80). Lastly, the discussion incorporated the lack of information across the industry: *"The Review heard from various sources, including the research community, that research is being done and/or new techniques to reduce injury and illness are being tested but the information is not being shared. When findings that show better ways to improve health and safety are not shared, they can't make a difference" (Mining Review, 2015, p.63).* Overall, this component of the theme illustrated that safety is a responsibility shared by every member of the industry.

Safety Culture: References that more distinctly used the term safety culture were used to describe who is influential in changing a culture, how deviance can become normalization throughout an organization, competing priorities of culture, evidence of poor safety culture. Who influences an organizations culture was discussed through identifying that all stakeholders are involved in establishing and influencing an organizations culture: *"all partners in Ontario's mining occupational health and safety system – the Ministry of Labour, the Workplace Safety and Insurance Board, the relevant Health and Safety Associations, the joint occupational health and safety committees or representatives and workers and employers – play a critical role in creating a health and safety culture"* (Mining Review, 2015, p.7). The discussion also reiterates the role of the mine manager, as their position of leadership can influence the entire organization: *"the role of the mine manager in creating and maintaining a culture that fosters worker participation and identifying and mitigating hazards is key to an effective IRS. The Review heard repeatedly that a single individual in a position of power and influence who is committed to resolving health and safety concerns and who believes in genuinely empowering a worker to*

participate and engage, can have a dramatic impact on the strength of the IRS" (Mining Review, 2015, p.56). The commissions also explored how "a *culture created a climate in which a disaster…could occur"* and how *"such total and catastrophic systemic failures can only be explained in the context of a culture in which wrongdoing became acceptable, where deviation became the norm. In such a culture, it was acceptable to mine coal with insufficient air; with buildups of coal dust; with inadequate rock dust..."* (Upper Big Branch, 2011, p.101). There was also a wealth of evidence related to how a culture of production challenges a culture of safety, for example: "*given the heightened production pressure in 2010, and problems with safety culture, it was not enough to assume that talking to staff and officials would result in proper compliance" (*Pike River, 2012, vol.2, p.142). Lastly, the reports numerous examples of situations leading up to the accidents which described poor safety culture within the organizations: "*Mr. Poynter also discovered a disabled safety device on the same machine, which should have increased concern about the safety culture at Pike and called into question the need for a much firmer compliance approach from the inspectors"* (Pike River, 2012, p.202). Therefore, the discussion inclusive of the term safety culture was focused on the organization and industry as a whole.

Belief

The belief theme contained no descriptors, other than belief (n=79). It was interesting to note that the references related to beliefs were not implicitly all related to safety beliefs. Instead, the term was predominantly used in three ways: to project the commissions' opinions, in testimonies or quotes, and to convey assumptions of what the belief may have been. To express the opinion of the commission, the term belief (or believe) was used to express unity and confidence in the findings, for example: "*had MSHA followed the mandates of Congress, and*

had ICG operated the mine with an eye firmly focused on miners' safety, there is every reason to believe that every person underground that day would have survived" (Sago, 2006, p.1). Such references therefore are speaking with the knowledge of the inquiry behind them and are projecting the opinion of the commission's authors. The second use relating to beliefs is illustrated in testimonies or quotes, for example, "*this was their stated belief...*" (Upper Big Branch, 2011, p.89), or "*it's my firm belief that they had no intention of complying*" (Westray, 1997, p.340). The last style of use was assumptions of beliefs, such as "*there appeared a belief...*" (Moura, 1995), or "*mine tragedies gave rise to a belief that, after an explosion, there was a window of opportunity within which it was possible to enter the mine safely*" (Pike River, 2012, p.221). Overall, the use of the word belief was used to express opinions, convictions, and confidence in findings that reflected the state of the organization.

4.5 DISCUSSION

The results of this study provide a unique insight into where, and how safety culture has been discussed through a sample of the last 50 years, of OHS mining commissioned reports. Accident inquiries rely on a large body of data, from a variety of sources to reach their conclusions and therefore, they provide a wealth of data (Stauch, 2012; Hopkins, 2015) that can help improve safety related outcomes. This study provides an opportunity to retrospectively analyze lessons from the past 50 years, and reflect on outcomes emerging from the context of individual reports, and within the dataset as a whole:

> *"Lessons learned can also turn into lessons forgotten if we do not understand the concepts, principles and theories behind failure and emergent properties" (Dien, Dechy & Stoop, 2012, p.1378).*

Safety culture was discussed using various terminology in all of the reports included in this study (1967-2015); however, it is interesting to note when the specific term ‘safety culture’ emerged in the discussion. While the term became prominent in other industries after the 1986 Chernobyl disaster, the reports included in this study indicate that the term did not appear to be adopted until the Westray investigation, in 1997. Further, it is interesting to note that safety culture was the dominant seeded term in the three reports published since 2010, from three different countries, and both coal mining and metalliferous mining (Figure 4.3). This is consistent with the evolving discussion across the safety science literature, with the widening of focus on organizational characteristics, as opposed to individual characteristics (Appendix 4).

The most dominant term related to safety culture identified was attitude. Attitude is defined as a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour (Eagly & Chaiken, 1993). Attitudes are preceded by cognitive, affective and behavioural processes, and in turn, attitudes produce cognitive, affective and behavioural responses (Guldenmund, 2000). Therefore, to extend this to the discussion of safety, safety attitudes refer to individual and collective beliefs about hazards and the importance of safety, together with the motivation to act on those beliefs (Pidgeon, 1991). Largely, the discussion around attitude centered on the attitude of management, which influences the organizational environment and subsequently the attitude of frontline workers. There were also numerous calls for a global change in attitude. Within the literature, it is extensively discussed that organizations often try to change attitudes without consideration for organizational features (Atkinson, 1990). Similarly, changes are often made to organizational systems without regard for individual behaviour or attitudes (Seddon, 1989). However, it is known that individuals are neither deterministically controlled by their environments nor entirely self-determining (Davis &

Powell, 1992). Bandura models this as a state of reciprocal determinism, where the individual and the environmental perpetually influence each other (Bandura, 1986; Bandura, 1977). Bandura's model has further been adapted (Cooper & Phillips, 2004; Cooper, 1996) to reflect the concept of safety culture. Researchers have applied Bandura's model to the workplace and proposed that the reciprocal causal factors that form an organization's safety culture are: the attitudes, perceptions and beliefs of individuals, their behaviours, and the safety management systems (Cooper, 2000). Therefore, understanding the role of individual attitudes, and the reciprocal relationship between the organizational environment and changing attitudes, is important for determining in what manner we achieve the necessary attitudinal and organizational change.

Similar to attitude, safe work behaviour, are critical considerations for a safety management system, because culture refers to patterns of behaviour. Therefore, modifying behaviour in an organizational context, by definition, modifies the culture (Hopkins, 2002, p.6): "if the behaviour is determined by the organization then the individual's values will shift accordingly, and if the organization constrains the individual to behave safely, the individual will begin to value safe behaviour more highly." Further, the behaviour of management and workplace leaders is instrumental in determining the culture of an organization. Consequently, if the behaviour of managers is modified, there is greater potential for organizational changes (Hopkins, 2002). Although behaviour modification has been shown to reduce accident rates in some cases, other researchers challenge that focusing on behavioural change diverts attention away from the deeper causes of accidents (i.e. understanding why people behave unsafely) (Hopkins, 2000). Therefore, safety behaviour and accidents should be observed at the group level rather than the individual level (Neal & Griffin, 2006).

The aim of most safe behaviour strategies is to identify behaviours that are not compliant with safe work procedures (Hopkins, 2002). Behaviour models identify the worker as the main cause of the accident, based on the tendency of humans to make errors under various situations and environmental conditions (Abdelhamid & Everett, 2000). The foundation of most behaviour models is the accident proneness theory (Abdelhamid & Everett, 2000). The accident proneness theory assumes that there are permanent characteristics in a person that make them more likely to have an accident. However, behavioural interventions aimed predominantly at workers, do not necessarily solve the potential for a serious event and can detract attention from addressing the behaviours of management and supervisors.

An important finding was related to how unsafe behaviours became the standard practices within many of the mines. This is consistent with Vaughan's (1996) concept of the normalization of deviance, applied extensively in her analysis of the Challenger Launch to explain what happened as a socially organized phenomenon. Cultures that accept the normalization of deviance often have conflicting messages, such as production over safety, resulting in poor safety compliance and safety participation. Safety compliance refers to the core activities that individuals conduct to maintain workplace safety, and adhere to the safety management system (i.e. wearing personal protective equipment) (Neal & Griffin, 2006), whereas safety participation describes behaviour's that do not directly contribute to an individual's personal safety but assist in developing an environment that supports safety (i.e. attending safety meetings) (Neal & Griffin, 2006). It is evident within many of the reports analyzed that safety compliance and safety participation were not normalized practices amongst workers, supervisors, or management, for example:

> *"The not-so-subtle message to employees is that MSHA is costing the company money – and workers shouldn't aid in that process. In an organization where deviance is not the norm, the same information might be used to deliver a very different message, 'We have some very serious safety problems at this mine, so much so that we've racked up a million dollars in penalties.'"* (Upper Big Branch, 2011, p.101)

In many of the reports, the normalization of deviance subsequently led to an increase in what is justified as acceptable risk. Risk taking and accident justification are generally the product of how an individual perceives their working environment, and is reciprocated through their compliance or noncompliance to the safety management system (Neal & Griffin, 2006; James & James, 1989). Further, the normalization of deviance can be utilized to understand the presence of a disconnect between safety standards and actual practices expressed in the inquiries. In many of the inquiries there were references to the legislation, safety systems, and standards present, and yet the accidents still occurred. This is similar to findings from Antonsen (2009) and Strauch (2015), that indicated the presence of a gap between perceived and actual demonstrations of safety. Vaughan (1996) found similar occurrences in the Challenger Launch, where the rules often still allowed for risk-taking and risk justification to occur.

Lastly, the concept of competence was consistently present throughout the entire timeframe. Competence referred to a range of inter-related factors, many of which are reflected in Reasons (1998) safety culture model, which references: learning, informed, reporting, just, and flexibility. Frequently it was referenced that there was insufficient competence amongst various individuals and roles in the companies that suffered the disasters. This relates to both the informed culture and learning culture referenced in Reason's model. An informed culture is defined as "a culture in which those who manage and operate the system have current knowledge

about the human, technical, organizational and environmental factors that determine the safety of the system as a whole" (Reason, 1997). Whereas, a learning culture refers to the willingness and competence of the organization to draw appropriate conclusions from the reporting and monitoring systems. The findings of the study demonstrated consistent concerns regarding the training and qualification system, for ensuring individuals are fully competent within their job descriptions. Further, there was evidence of a lack of an ability for the organizational structure to accommodate – reflecting the opposite of a flexible culture. There were also multiple references related to failures to report and heed warning signals. This relates to a reporting culture, which supports a feedback system between all levels of an organization that allows system failures to be caught prior to an accident occurring. Reason (1998) emphasizes that in order for a reporting culture to function correctly, it must be supported by a just culture which allows employees to trust they will be treated fairly by management (Gill & Shergill, 2004). All of the features discussed concern organizational practices, emphasizing that practices are the focal point of safety culture (Hopkins, 2002).

Consistent with what is widely accepted throughout the literature (Neal & Griffin, 2002; DeJoy, 2005), the role of management leadership emerged from the data as a dominant factor influencing the seeded safety culture terms. The role of management was mentioned in combination with attitude, attention, and commitment, amongst others, for example:

> "*Management's attitudes clearly shaped the manner in which the workplace functioned at Westray…Management failed to adopt and effectively promote a safety ethic underground. Instead, management, through its actions and attitudes, sent a different message - Westray was to produce coal at the expense of worker safety." (Westray, 1997, p.188)*

Previous research has demonstrated that management's commitment to safety, management style, and management visibility, are key indicators of an organizations safety culture (Flin et al., 2000). Further, it was also noted in the Roben's report (1972) that because management's role is diffused vertically in organizational hierarchies the dependence on senior management can be challenging due to competing concerns with other areas of the organization. This appeared frequently in the analysis, as it was evident that diversion of attention weakened the organizations ability to respond and mitigate safety issues. Therefore, there must be commitment from all levels of the organizational structure, initiating with a top-down organizational approach (Mohamed, 2003; Choudhry, Fang & Mohamed, 2007; Mearns et al., 2001; Antonsen, 2009; Hopkins, 2002).

Another concept that was consistently identified throughout the analysis was the internal responsibility system (IRS). The IRS refers to the concept of all parties in the workplace contributing to detecting and correcting workplace issues that can lead to injury and illness (Plummer, Strahlendorf & Holliday, 2000). Discussion incorporating IRS was evident within many of the references reviewed because of its proximity to the seeded safety culture terms, including: attention, attitude, behaviour, belief, competent, perceptions, and values. The references frequently discussed roles and responsibilities at different levels of hierarchy. Research has found that individuals at different hierarchical levels have different ways of conceptualizing and prioritizing work safety (Clarke, 1999). Groups with a greater proportion of members who fail to carry out safety behaviours, consequently accumulate a greater number of pathogens over time (Neal & Griffin, 2006). Therefore, noncompliance with safety procedures and refusal to participate in activities that enhance safety may not directly affect the person that fails to carry out the behaviour, but it may create the condition for someone else to be injured.

Responsibilities towards safety have a large influence on the overall safety culture of an organization.

Findings from the analysis also revealed similarities across the timeframe related to the propagation and penetration of the dominant culture throughout the organizations, which created various socially excepted practices. Often this was related to the messages instilled in front line workers from their perceptions of management, or from experienced workers. This relationship can be explained using the social exchange theory (Blau, 1964) and expectancy-valence theory (Vroom, 1964). The social exchange theory predicts that if an individual perceives that the organization is concerned about safety, they will reciprocate through safe behaviours (Neal & Griffin, 2006). The expectancy-valence theory predicts that employees are motivated to comply with safety procedures and participate in safety activities if they believe that these behaviours will lead to valued outcomes (Zohar, 2000; Neal & Griffin, 2006). It is evident from the findings of this study that the unsafe behaviours of many of the workers can be directly linked to how the organization led them to believe that safety was not the primary value. The role of management in the propagation of these negative cultures is further explained by Antsonsen (2009). Antonsen (2009) pointed out that organizational cultures typically are bias to reflecting the values of the dominant group, or subculture, in the organization. This is relevant to note because although organizational cultures can enhance organizational goals, they can also perpetuate negative behaviour, beliefs, attitudes, and values (Pidgeon, 1997). Therefore, to address cultures, as a form of resistance, focus must move beyond individual attitudes to shared cognitions and organizational structures.

In summary, the findings described in this paper are largely consistent with those of studies on safety culture in other industries; as there was limited discussion and inclusion of concepts

related to safety culture present within the text. This aligns with the knowledge that it is fairly uncommon for safety culture to be directly addressed in investigations of accidents (Stauch, 2012). Although limited, the presence of the seeded terms illustrated how complex, multi-faceted and pervasive safety culture is. Further, the results provide evidence of a positive transition away from viewing safety behaviour and accidents at the individual level, to observing accidents from a group level (Neal & Griffin, 2006), as evident from the increasing number of safety culture references, and the decreasing number of individual references (i.e. attitude) over the samples timeframe. Analyzing past accidents provides an opportunity to identify where the industry can improve its safety culture, and become a system which constantly identifies its own vulnerabilities. If the organization has a positive safety culture, the limitations of the safety system will be less influential (Hopkins, 2002).

4.6 LIMITATIONS

Although the study encompasses 50 years, 5 countries, and 10 reports, it is not without limitations. The development of the safety culture dictionary was conducted through a review of the literature, therefore there may have been additional terms throughout the evolution of the concept that were missed in the development of the dictionary. As there is currently no commonly accepted definition of safety culture there is no standard method of assessing the breadth of the concept. However, during the Leximancer analysis, in addition to the seeded terms, any related automatically-identified terms were extracted during the Generate Thesaurus phase through an iterative process (Leximancer Manual, 2014); therefore, decreasing the risk of missing any contextually relevant discussion. Secondly, although the sample itself was large in scope, including over 2,000 pages of data, there could have been a more diverse number of reports included. The countries included in the study were all English-speaking countries, that

are considered to have good OHS standards and practices. Therefore, having incorporated additional countries that may not have as robust standards for safety may have provided a more diverse discussion. Further, incorporating industries, other than mining, may have provided useful insight. Lastly, commissioned reports, or investigation reports, have the potential to be influenced by the authoring body. This study is limited to the interpretation of what was published, however, there may have been discussion throughout the investigation process that further discussed safety culture that was not captured in this data.

4.7 FUTURE RESEARCH

As this study has been a retrospective analysis, future research could focus on proactive measures of organizational culture. Proactive measures of safety culture can be utilized to analyze potential differences in how recommendations from commissioned reports are implemented in the mining industry. The results of this research could assist an organization's OHS personnel to identify how safety culture may influence the disconnect between the delivery of the safety recommendations and the implementation of the recommendation. Once these gaps have been identified, the plan to improve an organization's safety culture can be developed and implemented, from the top (management) to the bottom (underground miners at the rock face). This would allow future implementation of recommendations to result in greater compliance and improved safety related outcomes. In addition, once a report has been published and recommendations have been implemented within an organization, follow-up research incorporating measures of both the recommendation's uptake and the safety culture towards the changes must be completed. All of this information should then be used to figure out the best way to formulate, implement, and follow-up the implementation of recommendations.

Further, although the contexts of various work environments can be different, there is an opportunity to learn from occupational accident investigations and recommended practices from other countries, industries or variations within the same sector (i.e. metalliferous and coal mining) (Turner, 1978; Vuorio et al., 2013; Lind & Kivistö-Rahnasto, 2008). This research has further identified a new methodology for big data analysis that can assist in identifying trends over time, and learning opportunities from past lessons. This type of research and analysis could prove useful in other industries across the broader OHS landscape. This research is important for ensuring the lessons learned from previous accidents do not remain stagnant within reports, but instead these learnings reach and protect the miners from similar tragedies.

4.8 IMPLICATIONS & CONCLUSIONS

The findings of this study are based on a sample of OHS commissions from the mining industry, therefore the implications that can be drawn from the results are applicable primarily to the countries which authored the reports. Through the 2015 mining review, the mining industry in Ontario has acknowledged the role all stakeholders have in creating and maintaining a safety culture throughout the industry. This recent call to focus on the industry culture provides further support, for the relevance of this research. There is an opportunity to tackle the current recommendations with solutions that not only address hazards through engineering controls, regulating and legislation, but that incorporate a broader safety culture approach to eliminate latent organizational issues that may challenge new technologies in the future.

This historical analysis of the emergence and presence of safety culture in this sample of OHS commissioned reports in mining, reveals how the industry has progressed and adapted to advancements in organizational safety science. The concept of safety culture is multi-faceted

and incorporates a range of dimensions and terminology. This research provides a positive outlook on the broadening inclusion of safety culture in understanding accidents in the mining industry, and moves away from observing accidents from an individual level to an organizational level (Neal & Griffin, 2006). In addition, this study has further identified a new methodology for continued research in this area, using big data analysis techniques to learn from lessons of the past, without having to endure another industry accident.

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CHAPTER 5

GENERAL DISCUSSION

In this Chapter, the main findings of this thesis are summarized, and the implications for mining industry stakeholders are discussed. The broader applicability of the research findings across the OHS landscape are also presented, along with a discussion on avenues for future research.

5.1 OVERVIEW OF FINDINGS

The overall purpose of the studies presented in chapter 3 and 4 was to review the commissioned OHS reports in mining, over the past 50 years, in a two-step approach. First, it was determined whether there were any recommendations that appeared to be consistently identified in OHS commissions and reports; and second, how safety culture has been framed in the reports was explored.

The first objective was accomplished through content analysis. The objective of the initial phase was to determine if there were any recommendations that were stated in more than one of the ten, evaluated commissioned reports (Table 5.1). The second objective utilized a seeded analysis using, a computer assisted qualitative data analysis software (CAQDAS), to understand how safety culture was discussed in the same ten commissioned reports (Table 5.1).

Table 5.1: Overview of objectives and key findings from chapter 3 and chapter 4.

Title	Objectives	Key Findings
Chapter 3	• Identify if there were any recommendations that were repeated in mining inquiries, over the past 50 years. • Determine if similar recommendations were reported in coal mining and metalliferous mining.	• 49 sets of recommendations were repeated in multiple mining inquires, over the past 50 years. • These recommendations were grouped into 6 frames, as representative of the overall discussion presented through the recommendations. • Similarities were evident between coal mining and metalliferous mining; with the exception of recommendations related to physical hazards.
Chapter 4	• Investigate if/how safety culture was discussed in the reports.	• There were 964 safety culture terms referenced in a contextually relevant way. • 6 key themes emerged within these 964 references: safety culture, attitude, competence, beliefs, patterns, and norms. • The themes were reduced to define safety culture in two frames: the individual; and the organization.
	• Determine if references of safety culture differ between coal and metalliferous mining.	• Similarities were evident between coal and metalliferous mining.

5.2 IMPLICATIONS

During the analysis, the following quote from the Sago report (2006) stood out, as it emphasizes the importance of this thesis:

> *"The UMWA* [United Mine Workers of America] *made many of these same recommendations after the September 23, 2001 Jim Walter #5 disaster. Had they been implemented, the events at Sago, Alma, and Darby may have been avoided. MSHA* [Mine Safety and Health Administration] *has a responsibility to move forward with these recommendations immediately. The United Mine Workers of America and the nation do not*

intend to see more miners die as a result of regulatory inaction at any level of the government" (p.17).

The four mine disasters referenced in that statement alone, Sago (n=12), Alma (n=1), Darby (n=5), and Jim Walter #5 (n=13) took the lives of 31 miners due to electrocution, carbon monoxide poisoning, explosion forces; asphyxia; and thermal burns (Mine Safety and Health Administration, 2001, 2006, 2008). Based on the repeating recommendations highlighted in chapter 3, the list of events that "may have been avoided," had recommendations been implemented, could now include Upper Big Branch (2010) and Pike River (2012), amongst many others. The mining industry, including the various associations, companies, regulators, and governments that influence it, have a collective responsibility to act on the recommendations and enforce compliance with legislation. The following sections will outline how the findings of the presented studies are relevant to different stakeholders in the industry, and will utilize change management literature, learning theories, and accident investigations from other industries, to attempt to isolate why recommendations fail to be implemented or accepted into practice.

Mining Legislative Review Committee

Established under section 21 of the OHSA, the Mining Legislative Review Committee (MLRC) provides assistance, advice and recommendations to the Minister of Labour, regarding health and safety hazards affecting the mining industry (WSN, 2017a). The MLRC is comprised of representatives from both labour and management, and is facilitated by ministry staff. The MLRC also establishes sub-committees that focus on particular hazards, and assist in developing recommendations for proposed changes to regulations. The members of the MLRC may have interest in the findings of this study in two respects. First, recommendations aimed at

legislative and regulative changes were present in all commissions analyzed in chapter 3 (Appendix 3A), with numerous examples of overlap and repeating recommendations. Second, minimal safety culture concepts were identified in the chapter 4 analysis. Although safety culture cannot be legislated (Wood & Bandura, 1989; Hendry, 1996), one possible approach the MLRC could consider, is addressing how safety culture can impact regulation compliance, and how that in-turn impacts the formulation of legislative or regulative recommendations. This relates to the concept of the internal responsibility system (IRS).

In Ontario, the OHS act is founded on the IRS, which legislates that everyone in the workplace has a role in keeping the workplace safe and healthy (Government of Ontario, 2015). Further, it means that all employees have a statutory duty to report any unsafe situation to their employer or supervisor, and that the employers or supervisors are required to address the situation (Government of Ontario, 2015). The three basic elements of the IRS system are: the right to know, the right to participate, and the right to refuse unsafe work. Without a positive safety culture, the basic elements of the IRS system can be challenged. For example, if there is a culture of production/production pressure in the workplace, employees are less likely to refuse unsafe work, thereby propagating a poor safety culture. The 2015 Mining Review published two recommendations specific to the IRS (Recommendations 6.1 & 6.2). In order to adequately address these recommendations, the IRS and safety culture will need to be treated as interrelated concepts, that have the potential to impact regulation compliance. When a disconnect exists between the corporate culture and the change, culture can diminish the strength of the change initiative (Mento, Jones & Dirndorfer, 2002).

Of additional relevance to organizations like the MLRC, are the findings that were noted in the recommendation analysis (chapter 3), related to the choice of language used in the

formulation of recommendations. There were occasions where an initial recommendation 'suggested' a change, and the following report published x-years later would restate the recommendation with stronger language, such as 'regulate' or 'mandate.' For example, in 1981 it was recommended that "*that wherever practical, fall-on protection be installed on all man-operated underground equipment*" (Burkett et al., 1981, p.233), five years later in 1986 it was recommended that "*Fall-On Protection shall be mandatory on all vehicles operating in areas requiring this type of protection"* (Stevenson et al., 1986, p.69). In the change management literature, Mento, Jones & Dirndorfer (2002) stated that the process in which change is introduced sets the tone for recipients with respect to acceptance or rejection. Therefore, if a recommendation for change leaves room for interpretation errors, it may lead to organizational resistance. This may indicate a need for the MLRC to further consider how recommendations are formulated, and the specific semantic considerations for how they will be interpreted by industry.

Lastly, the MLRC recently established four new subcommittees to focus on the high-risk health and safety hazards in the Ontario mining sector, including: ground control, traffic management, water management, and ventilation and industrial hygiene (WSN, 2017b). The findings from chapter 3 identified recommendations from the studied reports that are relevant to members of each of the new subcommittees (Table 5.2 or Appendix 5A). This highlights an opportunity for the MLRC to investigate or reflect on why these recommendations are reappearing or what can be learned from previous attempts to implement related change.

Table 5.2 Summary of the number of recommendations pertaining to the Mining Legislative Review Committee's new subcommittees.

	1967	1976	1981	1986	1995	1997	2006	2011	2012	2015
Ground Control	1		1	34		3				2
Traffic Management							3	2		
Water Management						3				
Ventilation & Industrial Hygiene		73		1	8	23	16	9		3

Ministry of Advanced Education and Skills Development

In Canada, the *Constitution Act* gives exclusive authority to each province to make laws in relation to education. In Ontario, the Minister of Education and the Minister of Advanced Education and Skills Development (MAESD) are responsible for the administration of laws relating to education and skills training (MAESD, 2017). The MAESD is responsible for delivering training services, developing policy, setting standards for occupational training, particularly for trades under the *Trades Qualification and Apprenticeship Act,* and managing provincial programs to support workplace training and workplace preparation. Related to mining, workplace-based skills training is conducted through modular training delivered by the industry, compulsory under the *OHSA, and* administered by the Ministry of Labour. The MAESD modular training programs are then developed and delivered by accredited organizations, such as Workplace Safety North, Workers' Health and Safety Centre, and the Northern Centre for Advanced Technology which serve the Northern Ontario mining industry. The findings of chapter 3 identified recommendations related to training, education and competence in all of the reports analyzed (Table 3.6 and Appendix 3C) and provided insight into who, what, where, when, and how the industry learns. However, there were numerous examples of

recommendations related to training, education and competence that overlapped between reports. This suggest that there may be a disconnect between how learning is approached in the industry.

The literature on learning theory discusses the difference between learning opportunities for individuals, and organizational learning, and posits that learning at the organizational level is not necessarily the sum of the people learning. Instead organizational learning is captured and embedded in ongoing systems, practices, and structures, so that it can be shared and regularly used to intentionally improve changes in knowledge performance. In contrast to the literature, the findings from Chapter 3 found that recommendations related to training, education, and competence focused on the individual learners, in structured contexts, with minimal consideration for organizational learning, or learning culture. For example, recommendations frequently related to training for engineers or inspectors, and training specific to ground control and rock mechanics. These types of recommendations for structured training are supported through competency models (Marsick, 1988; Watkins, 1992); however, there is an increased awareness that valuable learning often happens informally on the job, in groups, or through conversations (Huber Institute for Learning in Organizations, 2002). This style of unstructured learning needs to be supported by a learning culture, that is embedded in the organization's capacity to adapt or to respond in novel ways while working to remove barriers to learning.

A key aspect of an organization's ability to capture new learning is how it facilitates the dissemination of that learning to current and future employees (Marsick & Watkins, 2003). The forecasted changes with staffing in the Ontario Mining industry, provide greater emphasis on the importance of organizational learning. It is projected that by 2018, approximately 50% of Ontario miners will exit the industry (Mining Industry Human Resources Council, 2009) creating large hiring requirements and training needs (Mining Industry Human Resources Council, 2013),

along with a loss of organizational knowledge and history that those workers may possess. It was reported that the Ontario mining industry usually has 14,900 new workers over 10 years; however, current estimates report that the sector may require up to 59,000 new employees by 2023 (Mining Industry Human Resources Council, 2013).

Kletz (1993) emphasized that "organizations have no memory; only people have memories and they move on" (p.4). Learning theory tells us that individuals learn by their own experience; however, it is unusual for the same accident to occur to the same person twice, and people are slower to learn from the experience of others. The concept of organizational memory is particularly relevant to the mining industry in the present because of the approaching retirement wave. The individuals that experience an accident, or are even employed by an organization at the time of an accident, are more likely to remember it. Therefore, changes that come of the accident are more likely to be understood by those workers. However, when those workers leave, the memory of why the change occurred may dissipate with them. Kletz (1993) suggests that to combat this dimming of memory, every instruction, code and standard should reference the reason why. For example, adding accounts of accidents that would not have occurred if the instruction, code or standard had been followed; describing old accidents, as well as recent ones, in safety bulletins and newsletters and discuss them; and develop better retrieval systems to more easily access details of past accidents in our own and other companies. Overall, what this reiterates, is that 'why' a recommendation is being put forward, should be connected and disseminated with the recommendation itself. This also emphasizes that it is not enough to hold individuals accountable for learning, an organizations capacity must also be built to support, encourage, and make use of that learning (Marsick & Watkins, 2003).

Future research should more specifically measure the mining industries' learning culture.

Marsick & Watkins (2003) developed the Dimensions of the Learning Organization Questionnaire (DLOQ) which measures shifts in an organization's climate, culture, systems, and structures that influence whether individuals learn. The DLOQ is based on seven dimensions of the learning organization (Marsick & Watkins, 1999; Watkins & Marsick, 1993, 1996):

1. Create continuous learning opportunities;
2. Promote inquiry and dialogue;
3. Encourage collaboration and team learning;
4. Create systems to capture and share learning;
5. Empower people toward a collective vision;
6. Connect the organization to its environment; and
7. Provide strategic leadership for learning.

Based on research conducted using the DLOQ, which measure organizations against the dimensions of the learning organization, a correlation between the learning organization dimensions and knowledge and financial performance is evident (Watkins, Selden, & Marsick, 1997; Watkins, Yang, & Marsick, 1997; & Yang, Watkins, & Marsick, 1998). The findings presented in Chapter 3 and 4, provide an initial step in seeing how the industry has learned from past experiences. If an organization has a strong learning culture, not only are the employees technically competent, but the organizational structure will be able to accommodate change, and identify and eliminate latent organizational issues that may challenge the system in the future (Reason, 1998).

Privy Council Office of Canada

In Canada, Commissions of Inquiry are established by the Cabinet, to fully and impartially investigate issues of national importance (Government of Canada, 2016). There are several types of Commissions of Inquiry established under *Part I* or *Part II* of the *Inquiries Act*, and federal statutes. Broadly, commissions are classified as advisory or investigative (Government of Canada, 2016). The findings of this study have additional relevance to how governments contemplating a future public inquiry and future commissions might approach it. Inquiries have the power to collect a wealth of information and provide opportunities to impact the industry in a substantial way. However, inquiries and reports are only effective if industries and governments learn from them. This thesis has shown that recommendations are reappearing in subsequent commissioned reports (Chapter 3, Table 3.4-3.9). Furthermore, the same themes as identified decades earlier reappear (Chapter 3, Figue 3.1), suggesting that the current process of calling for, completing, formulating, and implementing recommendations needs to be evaluated. The debate surrounding Royal Commission's or Inquiries has been discussed for over 150 years, with references of criticism in Canada dating back to 1849 (i.e. J. Toulmin Smith, *Government by Commissions, Illegial and Pernicious*). Lockwood (1967) pointed out, as demonstrated in Chapter 3, that many of the arguments advocated today, both for and against the validity and usefulness of Royal Commissions, are "simply a rehashing of opinions expressed more than one hundred years ago" (p.199).

In 2015, the Scottish Parliament published a report on the Inquiries into Fatal Accidents and Sudden Deaths Bill. This Bill was introduced with the aim of reforming the law in relation to fatal accident inquiries (FAIs). One of the key elements of this Bill is that when a Sheriff makes a recommendation, the relevant person/organization, whom the recommendations are

addressed, has 8 week to respond; explaining how they will implement, or why they will not be implementing the recommendation. This Bill stemmed, in part, from the results of a thematic review of FAIs which examined 88 cases of FAIs and involved representatives from the Mental Welfare Commission, British Transport Police, Air Accidents Investigation Branch, Maritime and Coastguard Agency, Marine Accident Investigation Branch, Health and Safety Executive, Healthcare Improvement Scotland, Care Inspectorate, Central Legal Office, and the Scottish Government. From this study, and the consideration of the former Bill, the Scottish Justice Committee acknowledged that recommendations "to prevent future incidents [were] not always implemented and lessons [were] not being learned from those accidents" (Scottish Justice Committee, 2015, p.33). Lack of implementation in the past was attributed to the lack of awareness of the party addressed through the recommendation. The dissemination of information is instrumental to the implementation of recommendations and compliance to the change. Organizations often fail to record and circulate the lessons learned from past accidents, or the recommendations never reach the recipient. The report also discussed the concept of making recommendations legally enforceable; however, this was overturned as it was acknowledged that recommendations may not always be realistic or affordable, or may cause issues with enforcement (Scottish Justice Committee, 2015, p.33-35). Therefore, the system of requiring rebuttals from the recommendation recipients is viewed as being of a greater advantage for creating change, and allowing recommendations from a particular inquiry to have the potential for broader implications in other contexts. The findings presented in this study, are therefore relevant to governments, commission counsels, lawyers, researchers, and others directly involved or influenced by future public inquiries.

Commissions are also the most expensive form of public inquiry, due to the length,

employment and administration fees (Prasser, 2006). It is often viewed that governments resort to Commissions on the basis of perceived prestige (Prasser, 2006). Governments have further been criticized for making appointments based on the electoral cycle. For example, typically a government will not appoint a commission that is scheduled to report too close to an election, as it may result in politically damaging findings. Lastly, Johnson (2000) reported that the use of obscure language often limits the ability to present information effectively. Therefore, it is recognized that not all inquiries are free from external influences, such as: the political landscape, the terms of reference, the legislation governing safety and the investigation process (i.e. time and resource constraints) (Quinlan, 2014).

Another consideration when conducting historical analysis of such reports, is the influence of how investigations are shaped by the current technical knowledge, dominant discourses and community structures during the time period when the commission was completed. Furthermore, preoccupations with certain influences can detract attention from other underlying failures, which can introduce bias into the final published report. For example, the inquiry into the Moura mine disaster (1995), a methane gas explosion killing eleven men in Australia, blamed the disaster on technical failures and management neglect. However, Hopkins (2000) studied the disaster using a sociological approach and identified that there was a very influential culture of denial, which led to misbeliefs of vulnerability to hazards, dismissing warning signs, and the normalization of deviance, contributing to the disasters occurrence. This illustrates that the best way to "prevent recurrence is not to focus on a discrete set of causes but to identify some background factor that, if changed, would prevent a recurrence" (Hopkins, 2013, p.5). This has also been evident in other studies following accident inquiries, such as Vaughan's (1996) rejection of the prevalent explanations of the cause of the NASA Challenger

disaster. The Presidential Commission into the disaster attributed the cause of the accident to a technical failure of the O-ring, which seals a critical joint of the solid rocket booster. Vaughan used a sociological approach to identify deeper root causes of the failure, including the culture at NASA and the normalization of deviance. Vaughan further described that NASA's culture provided "a way of seeing that was simultaneously a way of not seeing" (1996, p.394). Researchers must recognize that the findings identified in an investigation report are influenced by how the investigation was conducted and the political and social climate of the time. Although if done well, Commissions can help identify organizational weakness, the findings of repetition presented in Chapter 3, and the continued debate on the role of Commissions provokes additional reflection prior to establishing future Commissions.

Ontario Mine Rescue Technical Advisory Committee

The formation of the Ontario Mine Rescue (OMR) association came out of a recommendation published in the Royal Commission of Safety in Mines (1976), with the initial mandate to respond to underground mine fires, under the Department of Mines. Then, in 1986, the Report of the Provincial Inquiry into Ground Control and Emergency Preparedness in Ontario Mines recommended that the organization's mandate expand to respond to non-fire emergencies as well (Stevenson et al., 1986). Within the OMR is the Mine Rescue Technical Advisory Committee (TAC), established to promote the continual improvement of emergency preparedness of Ontario mines (WSN, 2017b). The OMR-TAC provides advice and recommendations regarding mine rescue emergency equipment requirements, research areas, and changes to the rescue handbook. Organizations, such as the OMR-TAC may have interest in the findings of this study, as emergency management and mine rescue recommendations were

identified in almost all reports in the 50-year sample (Table 3.7 and Appendix 3D). The OMR-TAC is currently working on topics including: team communication, heat stress, competency based training, refuge station design and developing an emergency response risk assessment tool, many of which have been discussed before (Table 5.3 or Appendix 5B). In approaching these projects, the studies presented in chapter 3 and chapter 4 provide insight into the benefit of looking at the lessons learned in previous accident investigations, as a starting point of establishing solutions that will stop the cycle of similar recommendations appearing. Further, if organizations such as the OMR-TAC consider the degree of overlap of rescue related recommendations presented in chapter 3 (Table 3.7 and Appendix 3D), and the minimal safety culture discussion from chapter 4 they may be able to develop a better approach for OMR emergency response. In Ontario, the OMR is the result of recommendations; this provides support for how valuable these recommendations can be if adopted by industry and government.

Table 5.3 Summary of the number of recommendations pertaining to the Ontario Mine Rescue Technical Advisory Committee Current Projects.

	1967	1976	1981	1986	1995	1997	2006	2011	2012	2015
Team Communication							6	6	2	1
Heat Stress										
Competency Based Training				1			6	2		
Refuge Station Design				1			3		1	
Emergency Response Risk Assessment Tool						2	8	1		1

Ontario Ministry of Labour

In 2015, the Ontario Ministry of Labour (MOL) published the Mining Health, Safety and Prevention review, which produced 18 recommendations, for the Ontario mining industry to address. Chapter 3 provides evidence of previous recommendations that overlap with 10 of the 18 recent recommendations (Table 5.4 or Appendix 5C). The results presented, and the

methodology utilized in this study, may therefore be of interest to the MOL. For example, the methodology presented in this study can be utilized for further studies incorporating other countries, industries, and different types of mining. This methodology can also be utilized to address specific recommendations, such as Recommendation 5.4 which speaks to the need for an aggregate analysis of all past inquests into mining fatalities, to improve future inquests in the mining sector. The MOL has access to numerous reports which contain a wealth of information that can reveal important considerations for prevention, and this big data methodology provides a proven means to learn from these past reports.

Table 5.4 Summary of the number of recommendations demonstrating overlap with the new Mining Health Safety and Prevention Review Recommendations.

		1967	1976	1981	1986	1995	1997	2006	2011	2012
Health & Safety Hazards	**1.1**									
	1.2		1							
	1.3									
	1.4									
	1.5									
	1.6		10						1	
New Tech. & Management of Change Process	**2.1**									
Emergency Preparedness & Mine Rescue	**3.1**					2	2		1	2
	3.2							2	3	
	3.3			2	1			4		
Training, Skills and Labour Supply Issues	**4.1**			1	2					
	4.2				4	1	1			
Capacity of the OHS System	**5.1**		1							
	5.2	4	5	3		2	9	2	1	2
	5.3									
	5.4									
Internal Responsibility System	**6.1**				6					
	6.2									

Mining Companies

Government agencies regularly use the argument that ‘safety pays’ as a way of motivating employers to attend to occupational health and safety (Hopkins, 1999). However, recent

approaches have attempted to use corporate social responsibility (CSR) frameworks to link organizations social responsibility beyond compliance with law, to investing in human capital, and managing relationships with social stakeholders that are affected by outcomes of the organization (European Commission, 2006). CSR provides a framework to connect OHS and welfare to other relevant aspects, such as: human resources, work-life balance, fundamental rights, environmental issues, safety and public health, profitability and productivity (Segal, Sobczak & Triomphe, 2003). If mining companies incorporated their business practices to integrate CSR-OHS, beyond legislation compliance it could potentially have a top-down influence that could improve the organizational safety culture. Further, although the cost of making a company safer can be high, the costs of not doing so can be much higher. The cost of an accident takes into consideration direct cost (i.e. medical experiences, lost time and production) and indirect financial costs (i.e. training replacement workers), as well as human costs (Reese, 2016). Lane (2016) said "successful businesses understand the importance of cost control; the cost of not prioritizing safety can be staggering - in both financial and human terms" (p.28). Therefore, mining companies may be interested in the findings of this study (chapter 3) as it highlights numerous direct and indirect costs repeating, as well as human lives being lost.

Through this studies analysis (chapter 3) numerous examples of the reports referencing the need to share information, accident data, safety equipment, etc. were identified. For example, the Pike River (2012) report mandated a *"compar[ison] with any similar matters in other countries"* (p.7). Upper Big Branch (2010) referenced that *"lifelines were already general practice in a number of other countries"* (p.47), and Sago (2006) said "*MSHA did not require the use of tracking devices to locate trapped miners underground, even though such technology has been available for over 30 years and is used widely in other countries*" (p.IV). The recent 2015

Mining Review has again recommended the need to share information on emerging injury and illness trends and information on incidents causing injury across the industry (recommendation 6.1).

Thirdly, large organizations, or industries, are comprised of different, and sometimes over-lapping social sub-groupings. Sinclair and Haines (1993) referenced examples, such as: air crew and ground maintenance; engineers and scientists; managers and workers; permanent staff and sub-contractors; site A compared to site B. Researchers have further identified that within these groups there can be additional distinctions of unique safety sub-cultures (O'Leary & Pidgeon, 1995; Gherardi, Nicolini & Odella, 1996). These references are only a small sample of the learning opportunities that were missed, or learned too late, and illustrate the importance of mining companies, and international safety organizations advocating and collaborating on opportunities to ensure they are always learning from others in the industry.

International safety organizations, such as the International Labour Organization have attempted to improve the sharing of knowledge, through databases, like the International Mining Fatality database (IMFD). The IMFD was created to establish a global record of all incidents, which caused fatalities in the last 142 years, with the majority of the data from 1980-2008 (when reporting regulations were strengthened) (MacNeill, 2008). However, there was large discrepancies with access to information and reporting practices from different countries. Other organizations like the National Institute for Occupational Safety and Health (NIOSH) publish 'Fatalgrams' which are factsheets that are shared across sectors when there is a fatality. Similar attempts at safety sharing have been evident in other industries, such as aviation. In 2003, the Netherlands recommended the creation of a combined air accidents investigation authority with Belgium, Germany and Luxembourg to concentrate air traffic data in one place and allow

learning to occur from each other's accident experiences, to eliminate repeat mistakes. Therefore, safety organizations may have an interest in the findings of this study as it provides a methodology for conducting big data analysis, that can identify trends in a range of safety data, to hopefully prevent future accidents.

5.3 FUTURE DIRECTIONS AND CONCLUSIONS

The finding from this thesis reiterate the importance of reviewing what has already been published to ensure that all possible lessons have been learned, and not forgotten, from the past. As recently stated in the Mining Review (2015, p.7):

> *"All partners in Ontario's mining occupational health and safety system – the Ministry of Labour, the Workplace Safety and Insurance Board, the relevant Health and Safety Associations, the joint occupational health and safety committees or representatives and workers and employers – play a critical role in creating a health and safety culture."*

The mining industry in Ontario is acknowledging the role all stakeholders have in creating and maintaining a safety culture throughout the industry; providing further support for the relevance of these findings. With the 2015 mining review, there is a new round of recommendations, and a new opportunity for researchers, and industry stakeholders to be reminded of what we can learn from past reports. Further, it is an opportunity to tackle the current recommendations with solutions that not only address hazards through engineering controls, regulating and legislation, but that incorporate a broader safety culture approach to eliminate latent organizational issues that may challenge new technologies in the future.

The studies presented in chapter 3 and 4 explored repeating recommendations, and provided insight into the broader conversation around safety culture, in mining. Acknowledging

that there were multiple sets of overlapping recommendations, paired with minimal discussion directly related to safety culture in the accident causation chain, suggests the need for further research to address this gap. As was explored in chapter 2, models of accident causation have evolved over time to reflect the shift in understanding from a basic outline of the sequence of events, to a broader representation of the whole system (Kataskiori, Sakellaropoulos & Manatakis, 2009). However, as is evident from the findings reported in this study (Figure 4.1), the concept of safety culture is only briefly discussed in the commission reports. This may indicate a need to further evolve the accident causation models, and subsequently the accident investigation methods, to better incorporate a broader range of causal factors. Doing so may be associated with different recommendations for improvement being produced (Kataskiori, Sakellaropoulos & Manatakis, 2009; Lundberg, Rollenhagen & Hollnagel, 2009). Although this is a debated topic, with some researchers arguing that the direct assessment of safety culture during accident investigations may produce misleading results (i.e. Strauch, 2015, others, such as Callaghan, of the Pike River (2012) investigation, believe that "to dismiss safety culture as too complex and intangible [would be] to ignore a core element of the disaster" (Vol. 2, p.174). New accident causation models, such as that developed by Bonsu et al. (2016) presented an accident analysis technique applicable to the mining industry, based on the existing frameworks complexity, and not adequately accounting for all the factors that contribute to accidents in mining. This model considers a far greater range of systemic factors (i.e. training and competency; contractor management; design; management of change; hazard identification; monitoring and auditing; maintenance management; resource provision; strategic decision/planning; risk management; leadership; work scheduling; and emergency response) and identifies ways in which the actions of top hierarchies of organizations contribute to an accident

process. Currently, the framework has only been applied to the investigation of the United States Jim Walter Coal Mine disaster in 2001. Therefore, future research may seek to validate this framework's relevance for the Ontario mining context, with the potential for becoming the standard of practice.

Further, as supported in the literature, organizational change research should be conducted longitudinally (Armenakis & Bedeian, 1999). The strength of conducting change research longitudinally, is that it captures how change emerges, develops, continues and terminates overtime (Van de Ven & Huber, 1990) and allows a more comprehensive understanding of the dynamics of change. A recent study published by Yau (2014) utilized an occupational safety culture index measuring the community's and employee's awareness, attitudes, and knowledge towards workplace safety and health in the Hong Kong construction industry from 1986 to 2013. The study found that the development of a safety culture noticeably reduced the number of accidents. Another study by Park (2013) analyzed methods of preventing noise-induced hearing loss in the workplace, over 40 years, in one company's hearing conservation program. The study found that the two key factors for successful culture change in this case study were leadership and action learning. Therefore, to build off the findings presented in chapter 4, and the success of similar studies in other industries, a longitudinal study would be required to determine if there is a link between organizations, an organization's safety culture, and indications of improved safety-related outcomes (such as performance of safe work practices (DeJoy & Southern, 1993; Griffin & Neal, 2000; Mattila, Hyttinen & Rantanen, 1994), safety program effectiveness (Cheyne et al., 1998; Zohar, 1980), and reduction in accidents, near misses, and other safety incidents (Dedobbleer & Beland, 1991; Gillen et al., 2002)) in the mining industry. Similarly, this could be conducted to identify specific elements of safety

culture, based on the Reason model (1998), such as an organization's learning culture, measured through uptake of recommendations for change, or resistance to change. Further, this study addressed only English language reports, therefore future studies could also examine reports from additional countries and mining regions, to gain an even greater global perspective.

Bernard Lewis (1975) distinguished three types of history: history remembered, where the knowledge of the past has been passed on without a break; history recovered, where knowledge of events have been completely forgotten but brought back to light; and history invented, where history is described inaccurately. Unless changes are made to the process of formulating recommendations, the history of mining accidents may reflect a fourth type of history: history repeated. The assessment of reactions to organizational change within the mining industry, following substantial reviews or commissions such as those included in this study, could provide insight into the consistent repetition and reframing of recommendations. Learning from literature relating to other industries, the culture of the organization influences its reaction to accepting or resisting change (Mento, Jones & Dirndorfer, 2002). Identifying barriers to change could then be considered in future frameworks for planning and implementing organizational change, OHS or otherwise. Further, this could assist OHS personnel in identifying how safety culture may influence the disconnect between the delivery of safety related changes and the implementation of recommendations. Once these disconnects have been identified, the plan to improve an organization's safety culture can be developed and implemented. This would allow future implementation of recommendations to result in greater compliance and improved safety related outcomes. Lastly, an additional component of commissioned reports should be a required measure of both recommendation uptake and the safety culture towards the change. Therefore, future studies should address the readiness to

change of the mining industry to identify best practices for formulating, implementing, and following-up on the implementation of recommendations. Ensuring the industries readiness to change would help make certain that lessons learned from previous accidents do not remain stagnant within reports, but instead these learnings reach and protect the miners from future tragedies.

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APPENDIX 2

Appendix 2D: Accident Investigation methods and applications as discussed by Kataskiori, Sakellaropoulos & Manatakis, (2009)

Accident Investigation Method	Year	Description	Application
Fault Tree Analysis (FTA)	1960	In FTA, an undesired event is selected and all possible elements that can contribute to the event are diagrammed as a tree in order to show logical connections and causes leading to a specified accident. The use of the tree allows investigators to represent graphically the logical combinations of causes of the defined top event. FTA is the most widely used of the tree techniques.	Department of National Defence.
Management oversight and risk tree (MORT)	1973	In MORT, the accident is defined as an unwanted energy transfer because of inadequate energy barriers and/or controls. The MORT diagram is a logic tree (the accident being the top event) with three main branches: the specific oversights and omissions associated with the accident being investigated, the assumed risks which are risks known but for some reason not controlled, and factors which are general characteristics of the management system that contributed to the mishap.	Large and bureaucratic organizations; nuclear industry.
Multilinear events sequencing (MES)	1975	MES is a charting technique, which shows events chronologically ordered on a time-line basis. It is based on the view that an accident begins when a stable situation is disturbed. The aim of the method is to help the analyst to identify the main actors and their actions and map the relations between the events along a flexible time line.	National Transportation Safety Board.
Bowtie Method	1979	The Bowtie method is used to analyze and demonstrate causal relationships in high risk situations. The bowtie analyses chains of events. It incorporates the fault tree, the event tree and causal factor charting. The bowtie also identifies control measures that an organization has in place.	Oil & gas industry, aviation, mining, maritime, chemical and health care.
Systematic cause analysis technique (SCAT)	1980	SCAT is presented as a chart which contains five blocks corresponding to five stages in the accident causation process, including: the accident description, the most common categories of contact that could have led to the accident, the most common immediate causes of this contact, the underlying causes, and safety management practices that should be addressed to prevent accidents from occurring.	Use in many types of accidents.
Causal tree method (CTM)	1978	The CTM attests that accidents result from variations or deviations in the usual process. There are four classes of variations: those related to the individual, the task, the equipment and the environment, respectively. The tree starts with the end event and works backwards. The analyst has to identify and list the variations and then display them in the analytic tree.	Use in occupational accidents.
Occupational Accident Research Unit (OARU)	1981	The method has two levels of reasoning: describing the accident sequence, and finding the determining factors. The accident sequence has three phases: the initial, the concluding phase, and the injury phase. The determining factors are technical, organizational and social properties of the production system that affect the accident sequence.	Investigating near misses in the nuclear industry.
TRIPOD	1994	TRIPOD follows Reason's accident causation model. The idea behind TRIPOD is that organizational failures are the main factors in accident causation. An accident occurs when one or more barriers fail. Unsafe acts (active failures) are the direct reason for the failure of barriers, which do not just occur but they are generated by underlying	Use in occupational accidents across all sectors of activity.

		mechanisms acting in organizations.	
Accident evolution and barrier function (AEB)	1991	The AEB approach is a stand-alone method and addresses safety barriers and their functions. An accident is modeled as a series of interactions between human and technical systems. The main principle is that it is possible to stop/interrupt the development of the sequence between any two successive errors (human or technical) through adequate barrier functions.	Use in complex accidents in the high-tech industries, and particularly for the oil Industry.
Integrated safety investigation methodology (ISIM)	1998	ISIM forces the investigator to look beyond the actions and decisions of front-line operators and into the latent unsafe conditions in the work system that provided the opportunity for the expression of those actions.	Use in transportation systems: aviation, railways, maritime and pipeline systems.
Norske Statesbaner (NSB)	2000	The method identifies the sequence of events and where barriers were broken or missing, and addresses factors such as procedures/documentation, training, communication, human-systems interface, tools and equipment, work preparation and local management, organizational management, work environment and task completion.	Developed specifically for the rail industry.
Work accidents investigation technique (WAIT)	2003	The method comprises two sequential phases: the identification of active failures in the sequence of events and the consequences, and the identification and analysis of individual and job factors and it finishes with the identification of organizational and management deficiencies.	Use in occupational accidents across all sectors of industrial activity.
Health and Safety Executive (HSG245)	2004	The aim of the analysis is to set out the reasons why the accident happened and find immediate, underlying and root causes. Immediate cause can be the agent of injury, underlying causes are unsafe acts and conditions and root cause is the failure from which all other failings grow, often remote in time and space from the accident.	Use in occupational accidents across all sectors of activity.
Control change cause analysis (3CA)	2007	The 3CA views an accident/incident as sequence of events in which unwanted changes occur. The method is designed to identify events in the sequence which are ‘’significant” in the sense that they reduce control and allow further unwanted changes to occur and identify barriers and controls that could have prevented them or limited their effects.	Use in occupational accidents across all sectors of activity.

Appendix 2E: Definitions of safety culture

Author	Definition
Mearns, Whitaker & Flin, 2001	That assembly of characteristics and attitudes in organizations and individuals, which establishes that, as an over; safety culture as a shared set of beliefs and attitudes by employees concerning the prioritization of safety issues and the maintenance of safe working conditions within the organization.
Mearns & Flin, 1999	Safety culture has been described in terms of values, beliefs, attitudes, social mores, norms, rules, practices, competencies, and behavior.
Hopkins, 2002	Safety culture is the assembly of characteristics and attitudes in organizations and individuals which establishes that as an over-riding priority ... safety issues receive the attention warranted by their significance.
Reason, 1998	Safety culture: as something an organization is (the beliefs, attitudes and values of its members regarding the pursuit of safety), and as something that an organization has (the structures, practices, controls and policies designed to enhance safety).
Cox & Flin, 1998	The beliefs, norms, attitudes, roles and social and technical practices concerned with minimizing the exposure of employees, managers, customers and members of the public to conditions considered dangerous or injurious.
Uttal, 1983	Definition of safety culture captures most of its essentials: 'Shared values (what is important) and beliefs (how things work) that interact with an organization's structures and control systems to produce behavioural norms (the way we do things around here)'.
Hale, 2000	Safety culture, on the other hand, refers to 'the attitudes, beliefs, and perceptions shared by natural groups as defining norms and values, which determine how they react in relation to risks and risk control systems.'
Fernández-Muñiz, Montes-Peón & Vàzquez-Ordás, 2007	A set of values, perceptions, attitudes and patterns of behavior with regard to safety shared by members of the organization; as well as a set of policies, practices and procedures relating to the reduction of employees' exposure to occupational risks, implemented at every level of the organization, and reflecting a high level of concern and commitment to the prevention of accidents and illnesses.
Pidgeon, 1997	Sometimes culture is discussed in terms of observable behaviour's (`the way we do things around here') and sometimes more as a system of symbols or meanings (for example, as a shared cognitive model, or as the assemblage of stories, arguments, myths, rituals and symbols that permeate organizational life). Note that the two approaches are to some extent interdependent, in that meaning often both constructs the `object' of inquiry and is in turn constructed itself through observable behaviour and material life.
Turner, Pidgeon, Blockley, & Toft, 1989	The set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimizing the exposure of employees, managers, customers, and members of the public to conditions considered dangerous or injurious.
International Nuclear Safety Advisory Group, 1991	Safety culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance.
Advisory Committee for Safety in Nuclear Installations (ACSNI), 1993	The product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine commitment to, and the style and proficiency of, an organization's health and safety management.
Zohar, 1980	A summary of molar perceptions that employees share about their work environments.
Glennon, 1982	Employees' perceptions of the many characteristics of their organization that have a direct impact upon their behaviour to reduce or eliminate danger (safety climate) and, safety climate is a special kind of organizational climate.
Brown & Holmes, 1986	A set of perceptions or beliefs held by an individual and/or group about a particular entity.
Cox & Cox, 1991	Safety cultures reflect the attitudes, beliefs, perceptions, and values that employees share in relation to safety.
Dedobbeleer & Bealand,1991	Molar perceptions people have of their work settings.
Pidgeon,1991	The set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimizing the exposure of employees, managers, customers and members of the public to conditions considered dangerous or injurious.
Ostrom, Wilhelmsen & Kaplan,1993	The concept that the organization's beliefs and attitudes, manifested in actions, policies, and procedures, affect its safety performance.

Cooper et al., 1994	Safety climate is concerned with the shared perceptions and beliefs that workers hold regarding safety in their work place.
Geller, 1994	In a total safety culture (TSC), everyone feels responsible for safety and pursues it on a daily basis.
Niskanen, 1994	Safety climate refers to a set of attributes that can be perceived about particular work organizations and which may be induced by the policies and practices that those organizations impose upon their workers and supervisors.
Coyle, Sleeman & Adams, 1995	The objective measurement of attitudes and perceptions toward occupational health and safety issues.
Berends, 1996	The collective mental programming towards safety of a group of organization members.
Lee, 1998	The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, and organization's health and safety management.
Cabrera & Isla, 1998	The shared perceptions of organizational members about their work environment and, more precisely, about their organizational safety policies.
Williamson et al. 1997	Safety climate is a summary concept describing the safety ethic in an organization or workplace which is reflected in employees' beliefs about safety.
Kennedy & Kirwan, 1998	An abstract concept, which is underpinned by the amalgamation of individual and group perceptions, thought processes, feelings and behaviors, which in turn gives rise to the particular way of doing things in the organization. It is a sub-element of the overall organizational culture.
Glendon & Stanton, 2000	Comprises attitudes, behaviors, norms and values, personal responsibilities as well as human resources features such as training and development.
Guldenmund, 2000	Those aspects of the organizational culture which will impact on attitudes and behavior related to increasing or decreasing risk.
Cooper, 2000	Culture is ‘the product of multiple goal-directed interactions between people (psychological), jobs (behavioral) and the organization (situational); while safety culture is ‘that observable degree of effort by which all organizational members directs their attention and actions toward improving safety on a daily basis.’
Mohamed, 2003	A sub-facet of organizational culture, which affects workers’ attitudes and behavior in relation to an organization’s on-going safety performance.
Richter & Koch, 2004	Shared and learned meanings, experiences and interpretations of work and safety - expressed partially symbolically – which guide people’s actions towards risk, accidents and prevention.
Fang et al. 2006	A set of prevailing indicators, beliefs and values that the organization owns in safety.
ACSNI Human Factors Study Group, 1993	The product of individual and group values, attitudes, perceptions, competencies and patterns of behavior that can determine the commitment to, and the style and proficiency of an organization’s health and safety management system.

Appendix 2F: Survey of OHS in mining leaders to identify commissioned reports

Dear: _____

I am a first-year student in the Master of Human Kinetics program at Laurentian University in Sudbury Ontario Canada and a graduate student member of the Center for Research in Occupational Safety and Health (CROSH). My research is being conducted in the field of Occupational Health and Safety (OHS) within the mining industry.

The initial phase of my research includes a systematic analysis of past OHS Commissioned reports that have addressed issues of health and safety within the mining industry. The main objective is to identify similarities and differences amongst the recommendations stemming from the selected reports that will be reviewed. I would like to include international reports that span several decades in my analysis.

I currently have access to the following reports:

- Report of the Tribunal Appointed to Inquire into the Disaster at Aberfan (1967)
- Report of the Royal Commission on the Health and Safety of Workers in Mines (1976)
- The Report of the Provincial Inquiry into Ground Control and Emergency Preparedness in Ontario Mines (1986)
- Report of the Westray Mine Public Inquiry (1992)
- Report on the Sago Mine Disaster (2006)
- Upper Big Branch: A Failure of Basic Coal Mine Safety Practices (2010)
- Royal Commission on the Pike Rover Coal Mine Tragedy (2012).

To ensure that the selection of commissions is comprehensive I am reaching out to several international leaders in OHS from Canada, United States, Australia, New Zealand and the United Kingdom to get their opinion on reports that I should consider in my analysis. If you have a few minutes it would be greatly appreciated if you could answer the following questions:

Are there any other English language OHS Commission or other OHS Reports concerning health and safety in mining (not listed above) that you would recommend I include in my analysis?

If yes, can you recommend the best way for me to gain access to a copy of the suggested report.

Thanks for considering this request. Your assistance is greatly appreciated.

APPENDIX 2D: List of experts consulted in report identification

Dr. Tammy Eger

Dr. Eger is an Associate Professor at Laurentian University in the School of Human Kinetics and Research Chair in Occupational Health and Safety with the Centre for Research in Occupational Safety and Health. Her research interests focus around the application of ergonomic and human factors principles in industry. She is an author of over 30 journal papers and 70 conference abstracts. She has received over 2 million dollars in research funding as a principal and co-investigator from the Natural Sciences and Engineering Research Council of Canada, Canadian Foundation for Innovation, and the Ontario Workplace Safety and Insurance Board. Prior to joining Laurentian University, Tammy worked as an Ergonomist with the Mines and Aggregates Safety and Health Association (now Workplace Safety North), and the Occupational Health Clinics for Ontario Workers.

Dr. Sandra Dorman

Dr. Dorman completed her Bachelors' degree in Biology from Guelph University and her doctoral degree from McMaster University in Physiology/Pharmacology; specializing in the area of immunology and respiratory physiology. Overall her research interests focus on health promotion and prevention of disease. This diversifies into three primary themes in the occupational setting: 1) airway physiology, specifically the link between the airways and the cardiovascular system in innate inflammatory responses to inhaled particles from various sources including smoke from forest fires, cigarette smoke, ambient pollution and diesel exhaust particles; 2) nutrition, specifically how Calories consumed supports energy demands on the job; 3) reproductive health in the workplace.

Mr. Vic Pakalnis

Mr. Pakalnis is the President and CEO of MIRARCO (Mining Innovation Reclamation and Applied Research) at Laurentian University. MIRARCO delivers quality research and innovative solutions to the global mining industry, related to: Geohazard Assessment and Risk Mitigation; Ventilation and Production optimization; Environmental monitoring and Rehabilitation; Energy, Renewables and Carbon Management; Climate Adaptation and Sustainable Communities. Mr. Pakalnis has been in the mining industry for over 40 years, holding positions such as: the Ontario Ministry of Labour's Chief Mining Engineer where he was heavily involved with the Provincial Inquiry into Mining Safety and Emergency Preparedness, Director of the Ministry of Labour's mining program, and Kinross Professor of Mining and Sustainability at the Queen's University Robert M. Buchan School of Mining.

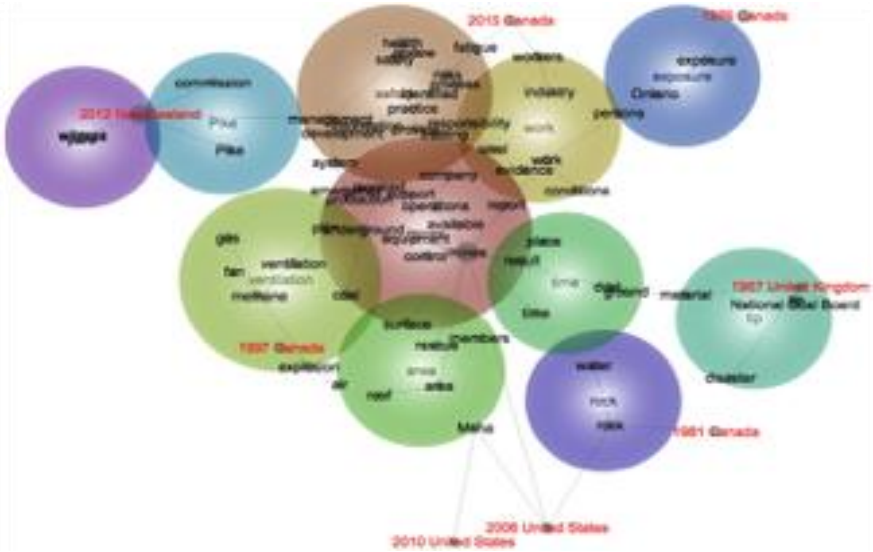
Dr. David Cliff

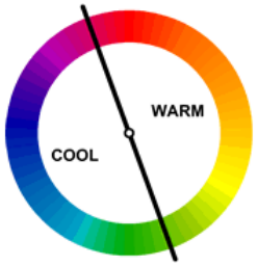
Dr. Cliff was a Professor of Occupational Health and Safety in Mining and Director of MISHC from 2011 to 2016, and was recently appointed Professor of Risk and Knowledge Transfer. His primary role is providing education, applied research and consulting in health and safety in the mining and minerals processing industry. Dr. Cliff has also served as the Safety and Health Adviser to the Queensland Mining Council, the Manager of Mining Research at the Safety in Mines Testing and Research Station. In these capacities, he has provided expert assistance in the areas of health and safety to the mining industry for over twenty three years. He has particular expertise in emergency preparedness, gas analysis, spontaneous combustion, fires and explosions, including providing expert testimony to the Moura No.2 Warden's inquiry, the Hazelwood Mine Fire Inquiry and the Pike River Royal Commission.

Dr. Patrick Foster

Dr. Foster is an Associate Professor in Mine Safety at the Camborne School of Mines, at the University of Exeter. Dr. Foster is a lecturing and researcher in: health & safety risk management, mine ventilation, surveying and thermodynamics; risk assessment; human factors and control assurance in the minerals industry. Dr. Foster is also the Mining Industry Representative on the UK EITI Management Steering Group, and a council member of both the Institute of Materials, Minerals & Mining, and the Mining Industry of the United Kingdom.

Appendix 2E: Interpreting Leximancer concept maps





When interpreting the concept map there are numerous elements that are considered:

1. **Concepts clustered** based on their co-occurrence will represent themes within the analyzed text with similar semantic contexts (Indulska & Recker, 2008; Smith & Humphreys, 2006; Cretchley et al., 2010b)
2. The **size of a concept** dot on the map will be indicative of the concepts strength within the body of analyzed text (i.e. the bigger the concept the more often it appears in the text) (Smith & Humphreys, 2006; Indulska & Recker, 2008).
3. The **brightness of a concept** dot on the map will be indicative of the concepts strength within the body of analyzed text (i.e. the brighter the concept the more often it appears in the text) (Smith & Humphreys, 2006 Indulska & Recker, 2008).
4. The **thickness and brightness of connections** between concepts will be indicative of the frequency of co-occurrence of the two concepts, as per the co-occurrence matrix (Smith & Humphreys, 2006; Indulska & Recker, 2008).
5. The **relative distance of concepts** on the map will be indicative of the degree to which the concepts appear together in the text (Smith & Humphreys, 2006; Indulska & Recker, 2008).
6. The **centrality of the concepts** in each map enables the identification of the most common risk concepts and themes for each report. When concepts are close together or overlap in the map, it means that they also appear close together in the text. Concepts that are directly related but not necessarily semantically linked, will be far apart on the concept map, while concepts that are strongly semantically linked will be close to each other on the concept map (Martin & Rice, 2007)
7. **File tags** will indicate the document that the concepts and themes originated from (Leximancer Manual, 2014).

APPENDIX 3

APPENDIX 3A

Table 3.4 Recommendations relating to regulation and legislation

1967	The ambit of the Mines and Quarries Act, 1954, is restricted by its long title to "the management and control of mines and quarries and for securing the safety health and welfare of persons employed thereat; to regulate the employment thereat of women and young persons; to require the fencing of abandoned and disused mines and of quarries; and for purposes connected with the matters aforesaid". Apart, therefore, from s. 151, which requires a disused mineshaft to be "provided with an efficient enclosure, barrier, plug, or other device so designed and constructed as to prevent any person from accidentally falling down the shaft," there is no requirement on the owners or manager of a mine to have regard to the safety of the general public. It follows that there is no obligation on the Inspectorate of Mines, in the exercise of its powers of securing the enforcement of the Act, to have regard to the safety of the general public. Indeed, s. 146 (1) which gives power to the Inspector to serve a notice for prohibiting or changing "any matter, thing, or practice at a mine" which "is or is likely shortly to become dangerous" repeats the limitation to the safety of persons employed at the mine. We recommend that this limitation in the Act be removed and that the owners and managers of mines, and also the Inspectorate of Mines, should be required to consider the safety, health, and welfare of all persons going about their lawful business in the vicinity of a mine, including the safety of their property. We have already indicated (ante paragraph 74) our view of the civil liability of mine owners to pay damages under the rule in Rylands v. Fletcher, but the disaster at Aberfan clearly indicates that substantially more is required to give that protection to the public which it is every citizen's right to expect. [Aberfan Page 129]
	Section 86 of the Mines and Quarries Act, 1954, ("All buildings and structures on the surface of a mine shall be kept in safe condition") should be amended so as to eliminate any doubt whether tips are "structures" within the meaning of the Section. [Aberfan Page 129]
	A duty should be imposed upon the manager to take such steps to obtain necessary information in relation to the tipping process as Section 48(2) of the Act requires him to take in relation to matters pertinent to the support of working places. [Aberfan Page 129]
	Using the power vested in him by Section 117(1) of the Act, the Minister should make an Order extending the Mines (Notification of Dangerous Occurrences) Order, 1959 (S.I. 1959, No. 2117) to tip slides and fires, "whether death or serious bodily injury is thereby caused or not", thereby ensuring that they are reported in accordance with Section 116 "forthwith ... to the Inspector for the District." [Aberfan Page 129]
	In order to ensure compliance with Section 86 in the amended form which we have suggested in (1) above, statutory provision should be made for regular inspections of all tips by persons competent to judge of their stability and safety and for the due recording of the nature, extent, and result of such inspections. [Aberfan Page 129]
	In addition, all tips (whether active or disused) should be subject to regular inspections by Her Majesty's Inspectorate of Mines and Quarries, whose resultant detailed reports should be published or otherwise made freely available to the local authorities concerned. [Aberfan Page 130]
	A statutory obligation should be imposed upon the owners and managers of mines to maintain and keep at the mine office an up-to-date plan of the surface area of the undertaking, to include the tipping area and contoured once the tip exceeds a height to be prescribed—say, at 20 feet. [Aberfan Page 130]
	The starting of a new tip or extension of an existing tip complex should be prohibited unless preceded by an adequate site investigation (i.e. in accordance with the normal Civil Engineer Code of Practice or the proposed new Code referred to earlier) and the submission to and approval by Her Majesty's Inspectorate of Mines of a tipping plan. [Aberfan Page 130]
	The existing Town and Country Planning Acts require to be amended so as to vest local planning authorities with greater control over the starting of new tips or the extension of existing ones. As to new sites, we favour the suggestion made by Sir Andrew Bryan that these should not be started until a report as to the suitability of the tipping scheme has been submitted to and approved by the planning authority. As to the continued

	use of an existing tipping site, we recommend that the General Development Order, 1963, be revised by adding to Col. (2) of Class XIX (3) a condition that such continued use after a given date (say, January 1st, 1969) be subject to the production of a similar report prepared by persons professionally qualified and satisfactory to the planning authority. If an impasse arises, the dispute should be submitted to the appropriate Minister and he should be vested with power to refer to an independent expert in the manner set out in paragraph 292 above. Provision should be made enabling the Minister to exclude, in a proper case, any claim for compensation if in the ultimate result permission to tip or to continue tipping is withheld or refused on grounds of safety. [Aberfan Page 130]
	All colliery tips being treated as engineering structures. They therefore suggest that the site investigation for a new tipping area or for the extension of an existing tip complex should be under the direction of a civil engineer experienced in soil mechanics. This approach (with which we entirely agree) is of fundamental importance. From this it would follow that: Maps prepared by Ordnance Survey and Geological Survey should first be looked at; A site investigation by using borings, soil-testing and observations of ground-water level should be carried out by a civil engineer, in consultation with a geologist and mining engineer or surveyor (regarding subsidence) where necessary; On the basis of this data, engineering proposals should be made by the civil engineer for the tip, including (where necessary) drainage and compaction; While the tipping process is continuing, the stability aspect should be under the control of a civil engineer; When tipping has been completed, inspection by a civil engineer should continue thereafter and routine measurements and observations made and recorded; The basic information so obtained should be placed on permanent record and be available to the local authority or to any person reasonably requiring it. [Aberfan Page 125]
	Recommend that the appropriate Minister should consider appointing such a Committee to advise him in the exercise of his responsibility for the safety and inspection of all tips, whether or not they are connected with mines or quarries. We do so for the following reason: The problem of tip stability is not by any means confined to coal-tips or even to coal-tips in the ownership of the National Coal Board. We have read that there are some 16,000 acres of derelict land in Wales alone, and that privately-owned tips comprise more than one half of this wasteland. And, as Mr. Philip Wien, Q.C., observed, as regards tips not in the ownership of the Board, there may be several categories; (1) tips belonging to other mining and quarrying interests; (2) tips belonging to industries not concerned with mining at all—for example, electricity authorities, steel works; and (3) the abandoned tips in the ownership of local authorities or private individuals". The proper constitution of the proposed National Tip Safety Committee would fall to be decided by the Ministers concerned after due consideration of the variety of interests involved. No doubt they would draw upon the fund of experience available in the Building Research Station and the Road Research Laboratory and the professional Institutions. [Aberfan Page 126]
	The National Coal Board should continue to have prime responsibility in respect of all tips in its ownership. It has within its own organization men of sufficient experience and qualifications to take all steps necessary for securing tip stability. Such dangers as arise are almost invariably in respect of active, working tips, and to take responsibility for their day-to-day management from the Board and vest it in any other body seems to us undesirable and even charged with dangerous possibilities. As the expert witness called on behalf of the Parents' and Residents' Association (Mr. Warded) said: "The disposal of refuse and the consequent problem of tip stability cannot be dissociated from the many other problems involved in the production of the nation's coal. The National Coal Board is fundamentally involved, firstly, from a policy point of view, because it has to assess the economic consequences of alternative methods of refuse disposal, and, secondly, from a technical point of view, in that it has to provide essential information about the nature and quantity of materials which have or may have to be disposed of and (because of possible statutory and Common Law liabilities) to make its own investigations and judgments about refuse-tip stability". [Aberfan Page 126]
	Accordingly, subject to the further recommendations which we hereafter set out, we consider that the public interest is best served by prime responsibility for National Coal Board tips remaining with the Board, which would at all times have available to it the advice of the National Tip Safety Committee. The Board could in return render valuable assistance to that Committee in relation to tips outside their ownership or control and (according to Hansard, Vol. 747, 6 June, 1967, col. 173-4) they already "have arranged courses of instruction in soil-heap management which are now being held throughout the country, and have offered specialist advice and assistance to local authorities and private owners in regard to spoil-heaps which are not the Board's responsibility". [Aberfan Page 127]

	Recommend adoption of, the suggestion made by Sir Andrew Bryan that the National Coal Board should prepare for consideration by the National Tip Safety Committee, with a view to its thereafter being issued publicly, a Code of Practice giving guidance on (a) features and factors that may give rise to or reveal instability in a tip, and (b) standards of safety called for in particular locations or circumstances. We attach in Appendix F Sir Andrew Bryan's suggestions as to the topics which should be covered by such a Code. But the vexed question remains: Within the National Coal Board itself, what organization should in future be responsible for tip safety and stability? We were told that during the Inquiry the lay-out of Board administration had been drastically altered, that Divisions and Groups had already been abolished and the whole country divided into 17 Areas, each headed by its own Area Director, and that the old South Western Division had become two Areas. And it was said in Parliament on June 6th last (Hansard Vol. 747, col. 173-4) that the Minister of Power had ascertained from the National Coal Board that, "A procedure has been established by the Board for technical and operational control over spoil heaps which includes frequent and regular investigations by specialists to ensure safety and stability". Furthermore, Mr. Wien, Q.C., told the Tribunal that in South Wales: "we have recently established a Tip Control Unit under the direction of Mr. Gareth Jones, the civil engineer, and he has got a complete team with independent experts to be consulted about old tips. They will give technical guidance to Areas on active tips or on the selection of new tips, and I daresay that when the Tip Safety Committee comes into existence this will be a matter that will be carefully considered by that Committee ... The Coal Board has been proceeding assiduously with training courses which have been held quite recently and all kinds of people (from Area Directors downwards, and including Area Civil Engineers from the rest of the country and Her Majesty's Divisional Inspector of Mines) have attended, dealing with tip stability. And in due course instruction will be given down to a very much lower level, to charge hands and foremen". When these assurances are implemented, the whole attitude in relation to tip stability should soon become dramatically altered. To ensure this, urgent consideration should be given to the appointment of civil engineers to the Inspectorate. [Aberfan Page 127]
	Recommend adoption of the suggestion advanced by Mr. Wardell that, should a local planning authority be dissatisfied about the stability of an existing or proposed tip after consideration of all the available information, the matter should be submitted to the Minister of Power with a request for a special investigation and report. Mr. Wardell continued: "If the Minister were satisfied that a prima facie case had been made out for further enquiry, it is suggested that the Minister should appoint an independent expert to conduct such an enquiry. The independent expert would require full authority to obtain access to all documents, plans, surveys and other information in possession either of the Board or the Local Authority and to any of their officials or employees concerned with tipping. He would also need to have authority to make his own inspection of the tip site or sites concerned and to require the Board or its agents to carry out additional investigations such as boreholes, trial pits, surveys, soil tests, etc., which he may require. In making his report the appointed expert should include recommendations as to whether: refuse disposal on an existing tip should cease permanently or be suspended until satisfactory investigations had been completed; in the case of a proposed new tip, whether the site was suitable for a tip or could be made suitable provided that certain specified precautions were taken; and in the case of an inactive tip, what action, if any, should be taken to render it safe". [Aberfan Page 127-128]
	Recommend that the appropriate Minister should consider appointing such a Committee to advise him in the exercise of his responsibility for the safety and inspection of all tips, whether or not they are connected with mines or quarries. We do so for the following reason: The problem of tip stability is not by any means confined to coal-tips or even to coal-tips in the ownership of the National Coal Board. We have read that there are some 16,000 acres of derelict land in Wales alone, and that privately-owned tips comprise more than one half of this wasteland. And, as Mr. Philip Wien, Q.C., observed, as regards tips not in the ownership of the Board, there may be several categories; (1) tips belonging to other mining and quarrying interests; (2) tips belonging to industries not concerned with mining at all—for example, electricity authorities, steel works; and (3) the abandoned tips in the ownership of local authorities or private individuals". The proper constitution of the proposed National Tip Safety Committee would fall to be decided by the Ministers concerned after due consideration of the variety of interests involved. No doubt they would draw upon the fund of experience available in the Building Research Station and the Road Research Laboratory and the professional Institutions. [Aberfan Page 126]
1976	That a Health and Safety in Mines and Plants Act, separate from the Mining Act, be prepared to replace part ix and the relevant sections of part xi

	of the Mining Act and be administered within an Occupational Health and Safety Authority established in the Ministry of Labour [Royal Commission Page 254]
	That the Health and Safety in Mines and Plants Act consist of a core of general provisions supplemented by regulations the issuance of which is authorized by the Act [Royal Commission Page 254]
	That the general provisions of the Health and Safety in Mines and Plants Act identify the duties and responsibilities of the Mines Engineering and Inspection Branch and the Occupational Health and Safety Branch [Royal Commission Page 254]
	That an Occupational Health and Safety Authority, encompassing the Mines Engineering and Inspection Branch, the corresponding branches under the Industrial Safety Act and the Construction Safety Act, and the Occupational Health and Safety Branch, be established in the Ministry of Labour under an assistant deputy minister [Royal Commission Page 254]
	That the Workmen's Compensation Board require and make provision for the inclusion in non-fatal injury statistics of all non-fatal injuries in which the injured person fails to return to his or her regular job on the day following the date of the accident giving rise to the injury [Royal Commission Page 121]
	That management inform the Joint Health and Safety Committee about its policies on rehabilitative work assignment and in the context of independent medical consultation seek the advice of the Committee in giving wise effect to its policies [Royal Commission Page 121]
	That the Mines Inspection Branch base its patterns of audits in part on studies of the relative risks involved in different segments of mining operations and on the related man-years at risk [Royal Commission Page 128]
	That the Occupational Health and Safety Branch publish biennially a critical review of factors that influence risks of accident and injury at workplaces in the mines and mineral plants [Royal Commission Page 130]
	That the Occupational Health and Safety Authority, in consultation with the Workmen's Compensation Board, industry, and labour, review the procedures for the reporting of injuries and accidents with a view to establishing links to occupational records and thereby facilitating accident research by sample methods [Royal Commission Page 145]
	That the senior management of each mining operation review the performance of its internal responsibility-system, placing special emphasis on the delineation of 1/responsibility to detect and to report departures from standard conditions at every level of operations, 2/ location of responsibility for ensuring that identified departures are dealt with. 3/ procedures for committing the resources to correct anomalies, and 4/ procedures for checking the action already taken and still to be taken [Royal Commission Page 152]
	That statutory provision be made for the appointment in each mine and plant of worker-auditors having the authority and responsibility to examine and report upon conditions of work pertaining to the health and safety of workers at sets of workplaces designated by management in such a way as to encompass all workplaces in underground, open pit. reduction plant, and shop and surface operations [Royal Commission Page 153]
	That worker-auditors be given released time with regular wages while performing their duties [Royal Commission Page 154]
	That the Workmen's Compensation Act be amended to make provision for the assessment of the costs of worker-auditors upon employers in class 5 [Royal Commission Page 154]
	That worker-auditors be appointed from among qualified candidates for a period of three years through the collective bargaining unit, where such exists, or be elected by the workers [Royal Commission Page 155]
	That there be statutory provision for the appropriate worker-auditor to participate in the investigation of fatal accidents and serious injuries [Royal Commission Page 156]
	That the designated worker-auditor have the privilege of cross- examining witnesses at an inquest into any fatal accident whose circumstances he has participated in investigating [Royal Commission Page 156]
	That there be statutory provision for the establishment of a Joint Labour-Management Health and Safety Committee at each mine and plant

	[Royal Commission Page 157]
	That the membership of the Committee consists of equal numbers of persons appointed by management and appointed by members of the collective bargaining unit(s), where such exist, and otherwise elected by the workers collectively, subject to the constraint that at least two of the persons selected be worker-auditors [Royal Commission Page 157]
	That the Joint Committee conduct its work as far as feasible during regular hours of work and that its members receive their regular wages while engaged on committee work [Royal Commission Page 157]
	That the Joint Committee meet regularly at least four times per year and not more often than once monthly [Royal Commission Page 158]
	That each mining company provide its employees with a written statement outlining its policy for health and safety and the organizational arrangements and responsibilities forgiving effect to it [Royal Commission Page 160]
	That on all shifts persons working alone be visited at the place of work at least three times (other than at the start of a shift) by a first-line supervisor [Royal Commission Page 174]
	That such visits may be reduced to once per shift (other than at the start of a shift) if 1/ work conditions are standard, and 2/ means of communication are provided and a record of use thereof is kept so that the person working alone reports his status to a point of supervision or to a designated fellow worker not less often than once every two hours [Royal Commission Page 174]
	That all fatalities and serious injuries to persons working alone underground be the subject of biennial review by the Occupational Health and Safety Branch [Royal Commission Page 175]
	That section 169(16)(b) be amended (and be included in a revised Act. to be recommended) to require the supervisor to make a written report which: 1/ states the nature of the condition of the machine or device which in the worker's belief renders it unsafe for use; 2/ gives the supervisor's comments at the time; and 3/ gives the supervisor's confirmation or otherwise that section 169(15) is, in the supervisor's view, satisfied [Royal Commission Page 176]
	That the worker who refers a machine or device to his supervisor under section 169(16)(b) as amended sign and receive a copy of the supervisor's report [Royal Commission Page 177]
	That where a worker after due consultation with his immediate supervisor, believes that the work then assigned cannot be performed by standard procedures without encountering personal risks deemed by him to be unreasonable, there be a statutory requirement that the work situation be examined and judged by a member of senior supervision in the presence of a worker-auditor acting as an observer and that a report of the circumstances be made to the mines inspectorate by the manager [Royal Commission Page 178]
	That the legal framework for the health and safety of workers in mines continue to recognize the importance of a significant component of collective self-regulation by industry as a whole achieved through a Mines Health and Safety Association [Royal Commission Page 46]
	That the management of each mining operation or appropriate part thereof be required under clearly defined statutory authority to prepare and keep updated a scheme of practice for implementing the foregoing codes [Royal Commission Page 49]
	That the management be required to appoint a competent person to supervise the over-all operation of the scheme [Royal Commission Page 49]
	That under the Workmen's Compensation Act provision be made for the levying on all employers in class 5 an amount of 0.03 per cent of wages currently subject to levy under the Act to create a fund for research on occupational health and safety by the joint labour- management health and safety committees [Royal Commission Page 239]
	That Section 53 of the Workmen's Compensation Act be amended as necessary to provide clear entitlement for rehabilitative compensation based on the principle of work adjustment for person's subject to exceptional exposure to environmental hazards at work [Royal Commission Page 57]
	That persons assigned to work alone be required to have specified qualifications for independent work at the job to which they are assigned [Royal Commission Page 174]
1981	That the chief executive officer of each mining company operating in Ontario review his personal commitment and contribution to the safety

	performance of his organization with a view to exercising his authority and leadership in the manner outlined. [Towards Safe Production Page 226]
	That where the Mining Health and Safety Branch identifies an operation as substandard, the district engineer meet with the manager of the operation to review performance and to advise of the branch's response, and further, that the branch so notify the chief executive officer by registered letter. [Towards Safe Production Page 226]
	That where the Mining Health and Safety branch identifies a company as having substantial performance, the director of the Mining Health and Safety' Branch meet with the chief executive officer of the company to review performance and to advise of the branch's response. [Towards Safe Production Page 226]
	That the Mining Health and Safety Branch review the cost indicator models being developed by the United States Bureau of Mines for metal mines and assess their applicability to Ontario mining operations. Using these cost indicator models, or some modification thereof, the costs of accidents to each mining company (by operation) be computed on an annual basis. [Towards Safe Production Page 226]
	That a company operating a mine or mining plant in Ontario include in its annual report a comprehensive statement of safety performance including relevant comparative data and a statement of costs incurred. [Towards Safe Production Page 226]
	That a workmen's compensation merit rating scheme, tailored specifically to the mining industry, be introduced. [Towards Safe Production Page 226]
	That the Mines Accident Prevention Association of Ontario carry out independent safely audits and that each mining company operating in Ontario consent to having the MAPAO perform an annual safety audit. [Towards Safe Production Page 226-227]
	That the individual companies be ranked on the basis of the audit results and that the ranking be made public by the MAPAO. [Towards Safe Production Page 227]
	That the number of first line underground supervisors employed by each mining company he sufficient to allow for at least two workplace contacts with each crew per shift and that the time allotted for these visits be sufficient to allow for adequate assistance and instruction to inexperienced crews and crews working in difficult areas. [Towards Safe Production Page 227]
	That wherever practical, a minimum of two group leaders for each first line underground supervisor he appointed. [Towards Safe Production Page 228]
	That individual work crews be more involved in the planning of their work and. in conjunction with group leaders, be made responsible for achieving short-term production targets. [Towards Safe Production Page 228]
	That first line supervisors assume an enlarged role as facilitators, resource persons, planners and safety auditors. [Towards Safe Production Page 228]
	That the ministry adopts an even-handed and consistent practice with respect to prosecutions and make known to the industry that it will not seek to prosecute a first line supervisor or any other employee unless satisfied that he or she has failed to take every precaution reasonable in the circumstances or has otherwise clearly acted negligently in complying with the Act and regulations. [Towards Safe Production Page 228]
	That each worker review his commitment to safe work practices and undertake to work in a safe manner at all times and to assume the full range of his responsibilities as a member of the direct internal responsibility system. [Towards Safe Production Page 228]
	That provision be made in law for a full-time worker safety' representative in each mine or mining plant employing more than 500 workers, and that where the number of workers in any mine or mining plant is less than 500, provision be made for the appointment of a worker safety representative to spend a proportionate amount of work lime engaged in safety related activities. [Towards Safe Production Page 228]
	That a worker safety representative hold office for a two-year term and work closely with the company's safety department. [Towards Safe Production Page 229]
	That a worker safety representative be a member of the joint health and safety committee otherwise qualified to scene in this position, and

	[Towards Safe Production Page 229]
	That a worker safety representative not be permitted to hold any union office or to engage in partisan union political activity of any kind. [Towards Safe Production Page 229]
	That a worker safety representative be paid the full amount he would have been paid had he continued in his classification. [Towards Safe Production Page 229]
	That a worker safety representative report all workplace anomalies to first line supervision and to the safety department and that only in the event that the condition is not corrected to the satisfaction of the worker safety representative within a reasonable period of time should lire matter be taken up with the joint health and safety committee. [Towards Safe Production Page 229]
	That the existing provisions of the Act which allows the minister to grant exemptions also apply to the election or appointment of worker safety representatives. [Towards Safe Production Page 229]
	That membership on joint health and safety committees be restricted to workers not holding other union positions and to line supervisors or managers, and that workers acting as committee members not be permitted to engage in partisan union political activities. [Towards Safe Production Page 229]
	That the chief executive officer and management of each mining company ensure that the joint health and safety committee is consulted on the full range of safety issues and that the documentation, data, materials and other information necessary for this purpose be made available to it. [Towards Safe Production Page 230]
	That the joint health and safety committee monitor the use of discipline as a tool in the achievement of safety objectives and make appropriate recommendations. [Towards Safe Production Page 230]
	That at least one of the worker members of the joint health and safety committee (preferably the full-time worker representative be given sufficient time to prepare the worker portion of the committee agendas and to investigate and inquire into the matters which are before the committee. [Towards Safe Production Page 230]
	That the worker members of the joint health and safety committee be provided with a private office (which may also double as the worker safety representative's office) equipped with adequate furniture and supplies and that typing and reproduction services be made available by the company. [Towards Safe Production Page 230]
	That in addition to assisting the line organization, the safety department within each company be made responsible for auditing the safety performance of the line organization. [Towards Safe Production Page 230]
	That the manager of the safety department has direct reporting access to senior executives responsible for the line organization including the chief executive officer. [Towards Safe Production Page 231]
	That each local union representing workers in Ontario mines and mining plants review its approach to health and safety matters and lake the steps necessary to commit itself to a course of union-management co-operation in health and safety administration. [Towards Safe Production Page 231]
	That each parent labour body actively encourage and support union-management co-operation in health and safety matters at the local level and co-operate with the industry in those health and safety endeavors which require the direct involvement of the parent body. [Towards Safe Production Page 231]
	That the Mining Health and Safety Branch advise the industry and its workers in writing of its policies and practices with respect to the enforcement of the Act and regulations and apprise the industry and its workers of any changes to its policies and practices or the adoption of any new enforcement initiatives. [Towards Safe Production Page 232]
	That the branch inspector meet with a worker representative and employer representative before commencing a workplace inspection and that these representatives be required to identify, in the manner described, all unresolved health and safety concerns. [Towards Safe Production Page

	232]
	That the branch inspector meet with these worker and employer representatives after the workplace inspection to review their previously identified concerns in light of the results of the inspection. [Towards Safe Production Page 232]
	That the branch inspector review, in the presence of the worker and employer representatives, the minutes of the health and safety committee meetings which have occurred since the previous inspection. [Towards Safe Production Page 232]
	That following each inspection, the branch inspector be ’required to file with his supervisor a written report on the performance of the responsibility systems at the particular operation. [Towards Safe Production Page 232]
	That the Mining Health and Safety Branch develop the capability of responding to relationship difficulties that and impeding health and safety performance. [Towards Safe Production Page 233]
	That the future recruitment of branch inspectors be based in part upon interpersonal dulls and that, in addition to their present duties, inspectors be assigned on-site monitoring or the direct and contributive responsibility systems at the workplace. [Towards Safe Production Page 233]
	That, wherever possible, branch engineers be relieved of work place inspection and be assigned the responsibility he investigation. pre-development review, consultation, educational activity and response to responsibility system breakdowns. [Towards Safe Production Page 233]
	That the tripartite committee responsible for reviewing the mining regulations study all recommendations made by coroners' juries investigating mining fatalities for possible general application and make appropriate recommendations. [Towards Safe Production Page 233]
	That whenever a contractor is engaged, the company meet with the contractor before commencement of the project to stipulate the safety requirements which must be met if the contractor is to be permitted to commence or continue the project. [Towards Safe Production Page 236]
	That the project be rigorously inspected by the company to ensure compliance with these requirements. [Towards Safe Production Page 236]
	That a mining company give preference in the awarding of contracts to contractors who have demonstrated satisfactory safety performance: and that the company consider a reward- penalty contract provision related to safety performance on the project. [Towards Safe Production Page 236]
	That the Mining Health and Safety Branch be advised by each mining company of all contract projects well in advance of the starting date of such projects. [Towards Safe Production Page 236]
	That the Mining Health and Safety Branch increase its regular inspections of these projects and. using its accident profile data, devote special attention to those contractors who demonstrate unsatisfactory safety performance. [Towards Safe Production Page 236]
	That a system of meriting for purposes of determining the amount of the Workmen's Compensation assessment for con tractors operating in the mining industry be established: and that separate rate groups be established for shaft sinking and mining contractors, general contractors and diamond drilling contractors. [Towards Safe Production Page 237]
	That the chief executive officer of each contractor engaged in projects for Ontario mines and mining plants review his personal commitment and contribution to the safety performance of his organization with a view to exercising his authority and leadership in the appropriate manner. [Towards Safe Production Page 237]
	That the Government of Canada incorporate by reference the Ontario Act and regulations, as amended from time to time, directly into the Canada Labour Code as a proviso covering uranium miners and plant workers, and also provide in the code that where the other provisions of the code and this provision arc in conflict, the latter shall apply. [Towards Safe Production Page 237]
	That the Government of Canada proceed by way of a reference to the Supreme Court of Canada by the Governor General in Council under section 55 of the Supreme Court Act. R.S.C. 1979 C S-19 and determine whether the federal jurisdiction is exclusive or concurrent. [Towards Safe Production Page 238]
	That the Governments of Canada and Ontario continue the arrangement under which the enforcement of statutory[1] health and safely requirements in Ontario uranium mines is assigned to provincial authorities. [Towards Safe Production Page 238]
	That individual mining companies and their respective unions agree to discontinue individual (or small crew) production incentive plans.

	[Towards Safe Production Page 238]
	That the government make known its intention to legislate an end to direct individual (or small crew) production incentive plans in Ontario mines if these plans arc not voluntarily discontinued. [Towards Safe Production Page 238]
	That a follow-up inquiry into the adequacy of safety practices and arrangements in Ontario mines and mining plants be undertaken commencing within three years of the release of this report. [Towards Safe Production Page 238]
1986	That the Ministry of Labour establish a Technical Support Centre with the following functions: to support an expanded role in pre-development review and annual mine design review as recommended elsewhere in this report; to establish facilities for training in ground control (although this should not conflict with existing established training programs); to develop, and provide to mines on short term loan, ground control instruments and testing equipment; to establish and maintain a computerized data base containing operational information on ground control and emergency preparedness and provide access to it to the mining industry, and to the research coordinating body recommended elsewhere in this report; to develop and maintain a library of computer software related to ground control technology, and especially to the interpretation of data from ground control monitoring devices; the specialist ground control engineers employed in the Technical Support Centre should not be involved in the regulatory functions of the Ministry; and the Technical Support Centre shall not be in conflict with the research coordinating body recommended elsewhere in this report. [Ground Control & Mine Rescue Page 68-69]
	That these inspectors enforce ground control regulations more vigorously. [Ground Control & Mine Rescue Page 69]
	That this Committee will remain seized with this study and will reconvene as necessary to discuss matters requiring further attention and to monitor progress on the implementation of these recommendations. [Ground Control & Mine Rescue Page 69]
	That companies reassess the effectiveness of their methods of providing information on ground control and emergency preparedness to employees. [Ground Control & Mine Rescue Page 58]
	That mining companies recognize that it is the responsibility of management to establish direct and effective communication between management and workers, and to ensure that adequate mechanisms exist for clear and timely feedback from workers to management. [Ground Control & Mine Rescue Page 58]
	That management should also ensure that mechanisms are in place to provide effective communication between workers on cross-shifts, and that these means of communication be available to both workers and supervisors. [Ground Control & Mine Rescue Page 58]
	That once developed and available these devices be installed in underground locations as necessary. [Ground Control & Mine Rescue Page 58]
	That any evaluations of ground conditions in areas being mined shall be given to the union representing workers in each mine, and shall also be communicated directly to the workers involved. [Ground Control & Mine Rescue Page 66]
	That mine design and subsequent implementation be under the direction of a technically competent person. [Ground Control & Mine Rescue Page 60]
	That every underground mine be required to prepare a ground control macro-environment design prior to the introduction of a new mining method, or the introduction of any expansion of the present mine design; such designs shall be submitted to the Ministry of Labour as required by Section 5 of the Mining Regulations. [Ground Control & Mine Rescue Page 60]
	That technically competent personnel of the Ministry of Labour review ground control design and procedures at all Ontario mines, at the mine site, at least once per year, and more frequently as required. [Ground Control & Mine Rescue Page 60]
	That the principles and details underlying the mine designs referred to in Recommendation 5.3 be communicated directly to persons concerned at all levels of the operation, including the appropriate officials of the union representing the mine crews; and that this communication take place before and during the implementation of the design. [Ground Control & Mine Rescue Page 61]
	That the Ministry of Labour review and monitor the regional stability affecting underground mines in Ontario, and discuss potential problems with the mining companies involved. [Ground Control & Mine Rescue Page 61]

	That mining companies sharing a common boundary exchange information that may affect the regional stability of either or both. [Ground Control & Mine Rescue Page 61]
	That workplace mining plans be made available to miners and be discussed with them, including any indications of abnormal ground conditions, geological anomalies, and the location of ground monitoring instruments, as a method of ensuring worker participation in planning ground control procedures in the "micro" environment. [Ground Control & Mine Rescue Page 61]
	This organization shall be funded by mining companies operating in Ontario, and by the federal and provincial governments. [Ground Control & Mine Rescue Page 51]
1995	The Inquiry recommends that the Act be amended to enable either proxy or alternative members to fill temporary or permanent positions on the panel or for an Inquiry to continue with a reduced number of panel members. [Moura Page 73]
	It is recommended therefore, that it be made a requirement of Part 60 (Second Working Extraction) submissions that spontaneous combustion be specifically included as a factor to be considered and evaluated. [Moura Page 72]
1997	Incentive bonuses based solely on productivity have no place in a hazardous working environment such as an underground coal mine. Such schemes should be replaced, where practical, by safety incentives that include three principles: The incentive plan should be developed cooperatively with the employees to whom it will be addressed; Both group safety performance and individual safety performance should be rewarded; All employees, whether underground or on surface — workers, supervisors, and middle managers — should be included. If properly instituted, such a safety incentive plan may well have its own productivity rewards. [Westray Page 188]
	The mandate of the Department of Natural Resources should be formally reviewed and clarified vis-a- vis the mandate of the Department of Labour to ensure that there are no gaps in the regulatory process. [Westray Page 404]
	A formal procedure should be put in place to provide for adequate communication and cooperation between the Department of Natural Resources and the Department of Labour to ensure that there is adequate provision for all aspects of the regulatory process. [Westray Page 404]
	The Mineral Resources Act should be amended to identify clearly the role of the Department of Natural Resources in monitoring mine planning in the province. Such a role should encompass the duty to make site inspections to ensure that an operator is mining in conformity with plans approved by the department. [Westray Page 405
	The Mineral Resources Act should be amended to identify clearly the role of the Department of Natural Resources in ensuring the "safe" operation of mines in the province. [Westray Page 405]
	The province should act to ensure that deputy ministers' positions are adequately described in detailed job descriptions. Such job descriptions should include but not be limited to the following requirements: Upon appointment, the deputy shall forthwith familiarize himself or herself with all the operations of the department as set out in a current organizational chart; The deputy shall have a working knowledge of all the legislation and regulations the department is administering; and Where there is more than one department with responsibilities for common projects or interests, the deputy shall ensure that proper procedures are instituted and maintained to provide adequate liaison with the other department or departments, with the result that no gaps exist in the administration of the legislation. [Westray Page 431]
	The Department of Natural Resources should no longer act as both promoter and regulator of the development of mineral and energy resources in the province, since this dual mandate constitutes a conflict-of-interest situation. The department should assume the role of helping the developer to formulate a plan that ensures both the safe and the efficient exploitation of the resource. The department must, first and foremost, work to ensure compliance with the general structure of the legislation in keeping with the purposes for which such legislation was enacted. [Westray Page 437]
	The structure and staff of the Department of Natural Resources should undergo a complete and intensive review, preferably by an outside agency, with the objective of establishing an efficient and responsible mechanism for the supervision and husbanding of our natural resources. [Westray Page 449]
	Visits by the inspectorate to the industrial site should not always be subject to prior notice. The inspectorate should schedule visits irregularly, and

	the operator should expect inspections at any time. Frequency of visits should be dictated by the safety performance of the operator. [Westray Page 488]
	The unacceptable performance of Claude White and Albert McLean in the conduct of their duties as mine-safety inspectors and regulators, coupled with their demeanour at the Inquiry hearings, must surely have destroyed any confidence the people of Nova Scotia might have had in the department's safety inspectorate. Accordingly, both White and McLean should be removed from any function relating to safety inspection or regulation. [Westray Page 506]
	The lassitude that paralyzed the inspectorate and rendered it ineffectual in dealing with Westray seems deep-seated and pervasive. Therefore, an independent and professional safety consultant should evaluate the inspectorate and its personnel. The consultant should make recommendations for the restructuring of the safety inspectorate and its staff to ensure that the workers and the people of Nova Scotia benefit from a competent, well-trained, and properly motivated safety inspectorate. [Westray Page 506]
	The Occupational Health and Safety Act, 1996, should be revised to incorporate the following changes: Except in the case of a demonstrated emergency, any communication respecting health and safety concerns should go initially to the first-line supervisor. If the first-line supervisor is unable or unwilling to resolve the matter, then the complaint should be taken directly to a member of the joint occupational health and safety committee, for resolution by the committee as expeditiously as possible. Provisions should be adopted to clarify how interests of non-union employees in a union shop will be met on the joint occupational health and safety committee. No member of management whose principal duty or concern relates to production quotas should be eligible for membership on the joint occupational health and safety committee. No member of the executive of any employee organization or union, or any person who has served in such capacity within the preceding year, should be eligible for membership on the joint occupational health and safety committee. Provisions should be adopted to define clearly the health and safety obligations of employees to workers on site who are employed by contractors other than the principal employer. Those contractor employees should have obligations similar to those of the employees of the principal employer. For greater certainty, the terms "serious injury" and "bodily injury" should be replaced with the one term "serious injury," defined as any injury that requires immediate medical aid or hospitalization or renders the employee unable to perform his or her regular duties for a period in excess of 24 hours. [Westray Page 510]
	The province of Nova Scotia should immediately study the British approach to ministerial responsibility, as illustrated by the publication Questions of Procedure for Ministers (1992), and move to adopt this type of program. Other jurisdictions should be canvassed for information on similar programs. The program adopted should include a codified and published statement of guidelines for ministers outlining ministerial responsibilities. The guidelines for minister’s program should be provided to all new ministers. It should include definitions of the nature and extent of the responsibility and accountability for the actions of the department over which a minister presides. A minister should have clear guidelines to the frequency and detail of division briefings and the circumstances under which the immediate division head should participate in the briefing along with the deputy minister. A minister should have access to independent advice about the nature and the extent of ministerial responsibility in specific situations. Such advice could be provided, ad hoc, by a person with recognized expertise in the field. [Westray Page 533]
	Any applicant for an underground coal mining permit should make a clear and unequivocal commitment to the concept of mine safety in the context expressed in the phrase — safe mine production. This clear commitment must be manifest in mine development proposals and plans. Therefore, before a mining permit is granted, the applicant should have to show that it has sufficient financial and other resources to ensure a reasonable margin of safety. The existence of this margin of safety will minimize the possibility that safety measures may be overlooked or avoided to maintain production schedules. [Westray Page 537]
	All rules and regulations relating to the operation of coal mines should be contained in Regulations made pursuant to the Occupational Health and Safety Act. The Coal Mines Regulation Act and the portions of the Mineral Resources Act dealing with operations should be repealed. [Westray Page 540]
	The regulator should be given authority to grant exemptions to or variances in the regulations if satisfied that such exemptions or variances will in no way detract from the safety of the miners and other underground workers. The burden is on the mine operator to demonstrate to the satisfaction

	of the regulator that safety considerations have not been prejudiced. [Westray Page 540]
	A mine developer or mine operator should submit all mine plans, including plans for the development, construction, or alteration of an underground coal mine, to the regulator for approval. No such plans should be acted upon or otherwise implemented until they have been approved in writing by the regulator. The regulator may require further detailed plans of the mine or the surrounding geological configurations. The regulator may require that the developer or operator have the plans, or portions of them, reviewed at the expense of the developer by mining consultants having expertise in any or all of the following disciplines: rock mechanics, mine ventilation, roof control, underground equipment, and electrical applications. [Westray Page 541]
	The province should take immediate action to reach agreement with the federal Department of Labour for the inspectorate of that department to assume the underground coal mine regulation and inspection functions currently under the aegis of the provincial Department of Labour. [Westray Page 542]
	The province should collaborate with the federal Department of Labour to draft updated underground coal mining regulations applicable to all coal mines in Nova Scotia. These common regulations would then be administered throughout the province by the inspectorate at present functioning under the provisions of the Canada Labour Code regulations. Such regulations should be drafted with the advice and assistance of competent coal mining professionals with demonstrated expertise in the various fields of ventilation, ground control, electrical applications, training, and mine rescue. [Westray Page 542]
	The province of Nova Scotia should review its occupational health and safety legislation and take whatever steps necessary to ensure that officers and directors of corporations doing business in this province are held properly accountable for the failure of the corporation to secure and maintain a safe workplace. [Westray Page 601]
	Consultants, when required, should be selected carefully to ensure that their background and expertise are consistent with the specific requirements of the problem to be analyzed. Any conflicts in the advice from these consultants ought to be resolved through discussion and, if necessary, through further advice. Conflicts in technical advice must be resolved, not ignored. [Westray Page 380]
	A legislative regime should be put in place to ensure regulatory involvement in all areas of ground control in which safety is a consideration. The regime should encompass planning approval, materials and equipment certification, and any other aspect of ground control having safety implications. [Westray Page 383]
	The legislation governing coal mines should be revised to ensure that every underground coal mine operator be required to engage, when required, the services of a qualified mining engineer with specialized post-graduate training in rock mechanics relating to coal mines. [Westray Page 385]
	Every position in amine should have a written job description setting out the duties and responsibilities of that position, with particular reference to safety. Each employee should be provided with a copy of his or her job description. A copy of all job descriptions should be prominently displayed in an area frequented by employees. [Westray Page 87]
2006	MSHA must re-establish itself as the government's advocate for miners. [Sago Page 17]
	Former coal industry executives should not be permitted to hold the highest offices within MSHA. [Sago Page 17]
	Future regulations must focus first on the health and safety benefits they afford miners. Considerations regarding cost benefits should not in any way negatively impact the protections miners enjoy. [Sago Page 17]
	In addition to the recommendations already made in this report and the MINER Act, MSHA must immediately take the following actions: Repeal the belt-air regulation; Require flame resistant conveyor belts in all mines; Move to increase the number and skill level of mine rescue teams; Lower the maximum exposure limit for respirable coal mine dust and silica; Update and expand training and retraining of miners; Develop a public hearing- style investigation process; Update the penalty and assessment scheme; Modify the conferencing process; Improve the certification and approval process; Assist NIOSH in developing the next generation SCSRs; Update permissible exposure limits for contaminants in the mine environment; Improve atmospheric monitoring systems; Develop a nationwide emergency communications system; Develop air

	quality, chemical substances and respiratory protection standards; and Address issues related to working in confined spaces. [Sago Page 17]
	The agencies must immediately take enforcement action against any operator that does not comply with the mine rescue team requirements. This action should include issuance of a closure order that stops production at all affected operations. Facilities so affected should not be permitted to resume operations until all aspects of the mine rescue team requirements are met. [Sago Page 16]
2011	Require a quarterly report certifying that all safety standards are being complied with. Sanction for knowingly or negligently falsifying the report would be the revocation of the mine superintendent's certification. [Upper Big Branch Page 109]
	Adopt provisions similar to those contained in the Sarbanes-Oxley Act to make a Board of Directors accountable for mine safety compliance. Boards of Directors should utilize existing health and safety committees or form a committee to oversee health and safety aspects of the mines under the company's control. The committee would be responsible for ensuring compliance with all federal and state regulations and would be required to certify that the mines are in compliance each quarter. A criminal penalty should be assessed on these board members who certify, negligently or willfully, that the mine is in compliance when it is not. [Upper Big Branch Page 109]
	Existing laws and regulations must be stringently and effectively enforced. Supervisors and managers are responsible for ensuring that front-line inspectors are provided equipment, tools, training and management support to succeed at their jobs. [Upper Big Branch Page 111]
	Inspectors are responsible for elevating to their supervisor's problems or concerns that the inspectors believe impede their ability to enforce the law. Likewise, supervisors and district managers are responsible for elevating issues to senior officials in the agency. [Upper Big Branch Page 111]
	When either state enforcement agencies or MSHA recognize a significant or persistent problem at a mine, the agencies should coordinate their responses. State and MSHA district offices should meet periodically to review problematic mines and formulate strategies to best protect miners. Cooperative efforts would maximize the effectiveness of the agencies against recalcitrant violators. [Upper Big Branch Page 111]
	MSHA should use its resources, and experienced and talented personnel to bolster its ability to notice the warning signs and see the big picture at mining operations with persistent health and safety problems. [Upper Big Branch Page 111]
	WVMHST should modify inspectors' work assignments to ensure that mines covering a large geographic area have an appropriate number of inspectors assigned to them, and that all mandatory inspections are completed. [Upper Big Branch Page 111]
	Management and labor in the agencies must discuss and negotiate terms to provide more flexibility for the days and hours in which mine inspections are conducted. If inspectors' work shifts are extended because of travel distance to the mine or demands at the mine, it is not unusual for the employee to complete 40 hours of work by Thursday. Currently, inspections on Fridays, Saturdays and Sundays are somewhat infrequent, but should be encouraged. An effective mine safety enforcement system should be flexible enough to facilitate inspections any day of the week, at any hour of the day. [Upper Big Branch Page 111]
	The current law, which states that no mine operator or anyone else should provide advance notice for federal mine safety and health inspectors, should be strengthened. Such a violation should constitute a felony. [Upper Big Branch Page 111]
	Government officials must ensure that adjudicating bodies have the personnel and resources necessary for speedy resolution of contested citations and penalties. [Upper Big Branch Page 112]
	Government officials must implement alternative dispute resolution mechanisms with appropriate means for worker involvement. [Upper Big Branch Page 112]
	State and federal officials must ensure that miners are aware of the protections afforded under state and federal law. An ongoing effort should be made to re-educate miners about the existence of the MSHA hotline and the state hotline and about the protections afforded them if they report unsafe conditions. [Upper Big Branch Page 112]
	When a mine is closed by a state or federal inspector's order, all affected miners would be entitled to full compensation by the operator at their regular rates of pay and work schedule for the entire period they are idled. [Upper Big Branch Page 112]

2012	To improve New Zealand's poor record in health and safety, a new Crown agent focusing solely on health and safety should be established: The Crown agent should have an executive board accountable to a minister; The chief executive of the Crown agent should be employed by and be accountable to the board; The Crown agent should be responsible for administering health and safety in line with strategies agreed with the responsible minister, and should provide policy advice to the minister in consultation with the Ministry of Business, Innovation and Employment; The ministry should monitor the Crown agency on behalf of the minister; The Crown agency should be funded by the current levies but the basis of the levies should be reviewed for high-hazard industries. [Pike River II Page 303]
	An effective regulatory framework for underground coal mining should be established urgently: The government should establish an expert task force to carry out the work. Its members should include health and safety experts and industry, regulator and worker health and safety representatives, supported by specialist technical experts; The expert taskforce should be separate from the ministerial task force that is reviewing whether New Zealand's entire health and safety system is fit for purpose; The expert task force should consult the Queensland and New South Wales frameworks as best practice; In the interests of time, the expert taskforce should consider the immediate development of approved codes of practice, to be replaced by regulation where appropriate; The expert taskforce should consider addressing urgently the specific issues identified by the commission including: the removal of the 'all practicable steps' qualification from the mandatory provisions of the regulations, including those relating to ingress and egress;-the provision of better health and safety information by the employer to the regulator, including notification of all high-potential incidents; requiring employers to have a comprehensive and auditable health and safety management system; mandating the statutory positions necessary to ensure healthy and safe mining (including a statutory mine manager and ventilation officer), and identifying their key functions and the relevant qualifications, competencies and training; defining standards for ventilation control devices, such as stoppings; defining the requirements of underground gas monitoring systems; prohibiting the placement of main fans underground and requiring them to be protected against explosions and other hazards, in accordance with the most appropriate international standards; clarifying the restricted zone within which electrical equipment requires protection; and updating electrical safety requirements in the light of new technology. [Pike River II Page 314-315]
	Regulators need to collaborate to ensure that health and safety is considered as early as possible and before permits are issued. [Pike River II Page 321]
	The Crown minerals regime should be changed to ensure that health and safety is an integral part of permit allocation and monitoring: The proposals in Review of the Crown Minerals Act 1991 Regime are endorsed; Mining permits should have a general condition requiring the need for compliance with the Health and Safety in Employment Act 1992 and regulations; The Ministry of Business, Innovation and Employment should provide information to prospective permit holders on health and safety laws and regulations; and The ministry should review the information required from applicants for mining permits and the way it assesses applications against the criteria in the minerals programme. [Pike River II Page 321]
	The statutory responsibilities of directors for health and safety in the workplace should be reviewed to better reflect their governance responsibilities. [Pike River II Page 328]
	The health and safety regulator should issue an approved code of practice to guide directors on how good governance practices can be used to manage health and safety risks. [Pike River II Page 328]
	Directors should rigorously review and monitor their organization's compliance with health and safety law and best practice. [Pike River II Page 328]
	The health and safety regulator should issue an approved code of practice to guide managers on health and safety risks, drawing on both their legal responsibilities and best practice. In the meantime, managers should consult the best practice guidance available. [Pike River II Page 331]
	Current regulations imposing general health and safety duties on the statutory mine manager should be extended to include detailed responsibilities for overseeing critical features of the company's health and safety management systems: The new regulations should have regard to the Queensland legislation applying to the mine's senior site executive; The statutory mine manager should be protected by new procedures

	requiring disclosure to the regulator when the employer does not accept the manager's proposals for improving health and safety. [Pike River II Page 331]
	Worker participation in health and safety in underground coal mines should be improved through legislative and administrative changes. Legislative changes should:require operators of underground coal mines to have documented worker participation systems; ensure all workers, including contractors, are competent to work safely, are supervised and are included in the mine's worker participation system; empower trained worker health and safety representatives to perform inspections and stop activities where there is an immediate danger of serious harm; require the results of monitoring and investigation of health and safety in the workplace to be automatically made available to workers; and allow unions to appoint check inspectors with the same powers as the worker health and safety representatives. The regulator should: issue an approved code of practice on employee participation; promote workers' rights and obligations through education and publicity; and ensure that inspectors routinely consult workers and health and safety representatives as part of audits and inspections. [Pike River II Page 336-337]
2015	The Ministry of Labour and the relevant Health and Safety Associations to increase their capacity to ensure the health and safety system has the resources to address mining hazards effectively – particularly the priority hazards identified in the risk-ranking exercise. In particular: Increase ministry capacity in geotechnical, mining, mechanical, electrical, structural, and civil engineering; and Increase system partners' technical capacity/ resources related to industrial hygiene and mechanical issues. [Mining Review Page 53]
	The Ministry of Labour to review its policies and procedures that apply to mining inspectors related to unannounced field visits, reprisals, repeat orders, the training of inspectors and the provision of information to workplace parties and how those policies and procedures are implemented. Take appropriate actions based on the findings of that review. In particular, address the following operational policies and procedures: Clarify the use of unannounced proactive field visits; Clarify the appropriate use of orders versus other methods to achieve compliance for priority hazards, especially with regard to repeated non-compliance with the same issue in a specific workplace; Clarify inspector action to be taken in situations of suspected reprisal; Align proactive activities, whenever possible, to the priority hazards identified in the sector level risk assessment; Clarify the training provided to inspectors to address priority hazards, and the inspector's role in the inquest process; and Identify any further training required to support changes in policies and procedures brought about by the Review and/or changes in the regulations. [Mining Review Page 53-54]
	The Ministry of Labour to work with the Ministry of Community Safety and Correctional Services to enhance the information supplied to the Chief Coroner's Office and build better linkages between both ministries. This collaboration includes: Conducting and regularly updating an aggregate analysis of all past inquests into mining fatalities; Holding information sessions with the Chief Coroner to identify opportunities for coroners to use the analysis to improve future inquests into fatalities in the mining sector. [Mining Review Page 54]
	The Ontario Mining Association to work with labour representatives to develop an Internal Responsibility System best practice guideline as an industry benchmark, to be endorsed by the Ontario Mining Association for implementation by its members. [Mining Review Page 59]
	The health and safety system to share data both on emerging injury and illness trends, and information on incidents causing serious injury across the industry to trigger preventative actions by workplace parties. [Mining Review Page 59]
	The Ministry of Labour to require mine operators to establish and implement a written management of change procedure, to include workers and the joint health and safety committee or health and safety representative. [Mining Review Page 35]

APPENDIX 3B

Table 3.5 Recommendations relating to occupational health and safety hazards

1967	None
1976	That the Occupational Health and Safety Branch of the province conduct or have conducted and publish on a regular cycle not exceeding five-years status reports on the evolution of occupational diseases among miners [Royal Commission Page 32]
	That the radiological status of silicosis in the dust-exposed population currently employed in the Elliot Lake uranium mines and all other uranium mines be reviewed by the Occupational Health and Safety Branch on a biennial basis for a period of at least ten years [Royal Commission Page 33]
	That the radiological status of silicosis among the persons on record on the Uranium Nominal Roll be reviewed on a biennial basis for a period of at least ten years [Royal Commission Page 33]
	That the functional purpose, measuring procedures, and measured results relating to all environmental monitoring at the workplace be made known in understandable language to all affected workers and their representatives by the employer and as appropriate by the Mine Inspection Branch [Royal Commission Page 40]
	That the Mines Inspection Branch within the Occupational Health and Safety Authority conduct annually, or have conducted by an independent agency, sample measurements at representative workplaces of all environmental quantities whose values are audited by the branch in carrying out its role [Royal Commission Page 43]
	That the Occupational Health and Safety Authority publish at least biennially a critical review of its appraisal of environmental conditions at the workplaces in the mines and mineral plants [Royal Commission Page 44]
	That the Mines Inspection Branch within the Occupational Health and Safety Authority, in consultation with industry and the representatives of workers, prepare, under clearly defined statutory authority, codes of practice applicable to all mines relating to: 1/ the prevention and confinement of dust at each distinctive class of workplace; 2/ the provision of ventilation in the breathing zone of workers that is effective for purposes of protecting health at each distinctive class of workplace (including vehicles) [Royal Commission Page 49]
	That the Occupational Health and Safety Authority establish by regulation a dust standard for personal exposure to free silica in mine and plant aerosols based on a time-weighted average of respirable dust intensity over a working shift and a stipulated lifetime period of exposure [Royal Commission Page 50]
	That the dust standard for time-weighted average exposure be established on a statutory basis [Royal Commission Page 50]
	That the Occupational Health and Safety Authority immediately establish by regulation an initial threshold limit value (11 v) for the mass of respirable free silica in milligrams per cubic metre [Royal Commission Page 50]
	That the interim has the status accorded by the Occupational Health and Safety Authority to threshold limit values as issued by the American Conference of Governmental Industrial Hygienists [Royal Commission Page 51]
	That the Occupational Health and Safety Branch prepare a code of requirements for the gravimetric measurement of dust in all mines suited to determining personal exposure to dust [Royal Commission Page 51]
	That all steps necessary to render effective a gravimetric standard of dust measurement, including those listed herein, be implemented immediately [Royal Commission Page 51]
	That to provide a basis for establishing a statutory standard or standards for time-weighted average respirable dust exposure in Ontario mines and plants, the Occupational Health and Safety Branch commission epidemiological research on the relation of the incidence of silicosis and of other pulmonary effects to the structure and quantity of aerosols respired in Ontario mines [Royal Commission Page 53]
	That where more than one recognized toxic component is present in the aerosols the standard specifies how an effective combined exposure limit is to be determined [Royal Commission Page 53]
	That the existing code of requirements for dust measurement in the uranium mines as issued by the chief engineer of the Mines Engineering Branch

	remain in force [Royal Commission Page 53]
	That the system of measurement and reporting being conducted by the Mines Accident Prevention Association continue in operation and be subject to independent monitoring as recommended [Royal Commission Page 54]
	That the current employees in the Elliot Lake uranium mines who are silicosis or exhibit dust effects (radiographic 4) in their lungs be eligible fora voluntary programme of work adjustment; that this programme be supported by management and unions; and that the Workmen's Compensation Board provide rehabilitative compensation and supportive counselling services to assist the persons involved [Royal Commission Page 57]
	That any employer who rotates job assignments for workmen with the intent of limiting the occupational exposure of any persons to any hazardous environmental condition be required to obtain the formal approval of the Occupational Health and Safety Branch and to maintain permanent occupational records which clearly define the persons, tasks, locations, hazardous conditions, and time intervals involved [Royal Commission Page 57]
	That during a programme of personal rehabilitation through work adjustment, and for a minimum period of two years thereafter, the income of the worker be maintained in accordance with the provisions of the Workmen's Compensation Act for full compensation which allow the Board to pay in non-taxable compensation 75 per cent of the difference between the current rate of pay and the rate of pay applicable at the date of entry into the programme [Royal Commission Page 58]
	That in addition to wage maintenance, the worker in a work adjustment programme be eligible for rehabilitation training allowances as provided for in the Workmen's Compensation Act [Royal Commission Page 58]
	That, further, the worker be entitled to reasonable costs for medical and personal counselling beyond that provided by the Workmen's Compensation Board, and to reasonable moving, travelling, and related relocation costs when these are applicable [Royal Commission Page 58]
	That when the lungs of a worker exhibit dust effects and the worker seeks the opportunity through work adjustment to take employment with a new employer, the new employer not be held liable for any disability pension or other costs for silicosis or disease conditions related thereto that may be levied as a consequence of the person becoming a silicotic at a future date [Royal Commission Page 59]
	That persons on the Uranium Nominal Roll who exhibit dust effects (radiographic 4) within twenty years of entry into Ontario dust exposure, and who have been employed in dust exposure in the uranium mines fora cumulative interval of five or more years from 1954 to 1975 inclusive, be eligible for rehabilitation assistance under a programme of work adjustment [Royal Commission Page 60]
	That where there is evidence that the exposure of any person to silicaladen dust has been substantially in excess of established dust guidelines or standards and the person has exhibited dust effects in his or her lungs within twenty years of first exposure to dust in Ontario, the person be eligible for work adjustment rehabilitation assistance [Royal Commission Page 60]
	That the Atomic Energy Control Board confirm the extent to which thoron gas and its daughter products contribute to the irradiation of the respiratory system and other organs of workers in Ontario uranium mines [Royal Commission Page 68]
	That the Occupational Health and Safety Authority be given by statute the authority and responsibility to conduct a full and expeditious review of any emergent situation in which the health and safety of workers in mines are believed to be at unexpected risk [Royal Commission Page 78]
	That the Occupational Health and Safety Branch commission a review of the mortality experience of persons on the Ontario Uranium Nominal Roll on a biennial basis for at least ten years [Royal Commission Page 80]
	That the Atomic Energy Control Board review the basis for and issue explicit regulations establishing the maximum permissible annual exposure to ionizing radiation for workers in uranium and thorium mines and mills [Royal Commission Page 86]
	That the regulations for maximum permissible exposure delineate how all significant components of external and internal irradiation are to be accounted for and indicate how total exposure and related dose is to be evaluated [Royal Commission Page 86]
	That the regulations for maximum permissible exposure and related dose be interpreted in units that can be monitored by practical means in uranium and thorium mines and mills [Royal Commission Page 86]

	That the Province of Ontario, through the Occupational Health and Safety Authority, establish by statute a standard for maximum permissible annual exposure to ionizing radiation for workers in uranium and thorium mines and mills, and that this standard be in conformity with the regulatory standards of the Atomic Energy Control Board [Royal Commission Page 87]
	That the Occupational Health and Safety Branch be assigned by provincial statute the responsibility to direct: the establishment and review of occupational health records for workers in uranium and thorium mines and mills, for regulatory and epidemiological purposes; the preparation of a code of practice for the sampling and measurement of ionizing radiation in a manner suited to the determination of the exposures of individual workers in uranium and thorium mines and mills and that this code of practice be in conformity with the code of guidance issued by the Atomic Energy Control Board [Royal Commission Page 87]
	That the Mines Inspection Branch prepare regulations defining the kinds and frequencies of measurements of ventilation, dust and radiation necessary to enable it to audit the engineering operational characteristics of uranium and thorium mines and mills [Royal Commission Page 88]
	That these regulations be in conformity with the related code of guidance established by the Atomic Energy Control Board [Royal Commission Page 88]
	That the Occupational Health and Safety Authority specify: a level of radiation in mine or mill air measured at any time in any occupied workplace which, if exceeded, requires that corrective action be taken immediately; and a level of radiation in mine or mill air measured at any time in any occupied workplace which, if exceeded, requires closure of the related workplace until the level of radiation is reduced below that specified in 1 [Royal Commission Page 88]
	That the Occupational Health and Safety Branch commission a study of the mortality experience of the Ontario Uranium Nominal Roll relative to appropriately matched sample populations of non-uranium miners and non-miners in Ontario [Royal Commission Page 91]
	That persons who work in exposure to ionizing radiation in uranium mines cease smoking both at home and at work for their own sakes and in consideration of their families [Royal Commission Page 96]
	That each uranium mine install a central monitoring system for its ventilation network to monitor air flow and air quality as indicated by dust, radiation, and other contaminants [Royal Commission Page 102]
	That the Mines Inspection Branch audit the engineering records of performance of mine ventilation systems [Royal Commission Page 102]
	That job rotation within mines conducted to meet the standard foi maximum permissible annual exposure to ionizing radiation be permitted only in exceptional circumstances with the explicit approval on a case-by-case basis of the Occupational Health and Safety Branch and with the knowledge of the representatives of the workers [Royal Commission Page 105]
	That records of personal exposure to ionizing radiation maintained by the mines be keyed to Miner's Certificate numbers in sequence and to social insurance numbers in sequence and arranged in a format that facilitates linking to the Mining Master File [Royal Commission Page 107]
	That the frequency of regular radiographic examination of dust- exposed mine workers be reduced to once every two years unless a radiographic change was apparent at the last examination [Royal Commission Page 107]
	That tests using sputum cytology be conducted every two years on all persons who have worked in radiation exposure at the uranium mines for five or more years [Royal Commission Page 108]
	That the Workmen's Compensation Board of Ontario, in collaboration with other provincial boards as provided for in interprovincial agreements, seek out and advise the families of all ascertained deaths due to lung cancer on the Nominal Roll that a claim for compensation should be entered [Royal Commission Page 109]
	That there be a statutory requirement fora metallurgical audit of origin, holdup, and destination of potentially dangerous minor elements such as lead, mercury, arsenic, selenium, tellurium, cadmium, and antimony to be conducted quarterly in all reduction plants on the basis of extended standard monthly sampling and analytical procedures, and that a copy of this audit be sent to the Occupational Health and Safety Authority [Royal Commission Page 200]

	That there be a statutory requirement for an annual audit of use by mass of toxic and hazardous reagents and that a copy be sent to the Occupational Health and Safety Authority [Royal Commission Page 200]
	That there be a statutory requirement for each mining company to maintain a register of servicing chemicals involved in any personal encounter associated with a medical aid or compensable injury; that the register specify both trade name and chemical composition and identify all known toxic chemical constituents; that the register include an audit by mass of annual use; and that a copy of this register be provided to the Occupational Health and Safety Authority [Royal Commission Page 204]
	That there be a statutory requirement for each mining company to give the Occupational Health and Safety Authority notice of intent to introduce any new reagent or servicing chemical whose toxic characteristics are not known [Royal Commission Page 204]
	That with respect to codes of practice and schemes of practice the principles of recommendations 8, 9, and 10 be extended 1/ to the maintenance and operation of mills and metallurgical plants as these activities relate to the leaking and spilling of toxic substances and hot materials into workplaces; 2/ to the handling and use of reagents and servicing chemicals and to the consequences of their leaks and spills [Royal Commission Page 204]
	That at any location of regular work where acute encounters with toxic substances repeatedly occur as a result of leaking, recirculating, or spilling from metallurgical and milling processes, there be a statutory requirement for the installation and use of equipment for the continuous monitoring of the substances involved [Royal Commission Page 206]
	That a record of the substances and human effects of acute encounters with toxic substances leading to medical aid and compensable injuries be maintained in the occupational health records of each worker at the company level [Royal Commission Page 207]
	That at five-year intervals the Occupational Health and Safety Branch commission a review of the status of the health of samples of persons who are at high risk from acute encounters with toxic substances, including as necessary intensive medical surveillance [Royal Commission Page 207]
	That epidemiological reviews of selected populations subject to chronic exposure to toxic substances in reduction plants and mines matched to suitable control groups be conducted on a five-year cycle by or under the guidance of the Occupational Health and Safety Branch and that the essential results of such studies be summarized and published upon completion [Royal Commission Page 212]
	That a nominal roll of workers at risk of exposure to nickel carbonyl in reduction plants and pilot plants be established by the Occupational Health and Safety Authority, in co-operation with the industry and that the morbidity and the mortality experience of this nominal roll be reviewed at least every five years [Royal Commission Page 213]
	That the appropriate substance or intent of recommendations 8, 9, 10, 39(2), 40, 42, and 46 be made applicable to asbestos mines and plants [Royal Commission Page 215]
	That the Occupational Health and Safety Authority establish, with the co-operation of the Workmen's Compensation Board and the mining industry, a nominal roll of all persons who have worked one or more months in exposure to asbestos dust in asbestos mines and plants [Royal Commission Page 215]
	That workers in reduction plants who have been exposed for twenty years or longer to sulphur dioxide at levels approaching the current Threshold Limit Value and to associated dust and fumes, and who exhibit the clinical diagnosis of chronic bronchitis and impaired pulmonary function as identified by objective tests, be considered for compensation at up to a maximum of 20 per cent disability [Royal Commission Page 219]
	That the Occupational Health and Safety Authority, in co-operation with the industry and labour, prepare a code of requirements for diesel emissions [Royal Commission Page 222]
	That the Mines Inspection Branch prepare a code of practice for the provision of ventilation and for the fuelling, operation, and maintenance of diesel engines [Royal Commission Page 222]
	That each mine using diesel equipment be required to file with the Mines Inspection Branch a scheme of practice for the short-term and long-term maintenance of its diesel engines [Royal Commission Page 222]
	That each mining operation maintain noise maps based on full-scale conditions of operation which delineate all areas of work at which the noise level

	is 85 dB(A) or higher [Royal Commission Page 229]
	That the mining industry and equipment manufacturers, with the Canadian Standards Association, expedite the development of standards for the assessment of noise from mining equipment, and for the performance of personal safety equipment and cab enclosures in attenuating noise, and that such standards be invoked by the industry in specifying noise performance requirements for new equipment [Royal Commission Page 230]
	That the Occupational Health and Safety Authority issue a code of practice for the selection and use of personal hearing protection and for communicating in the presence of noise [Royal Commission Page 231]
	That, by statute, each mining company be made responsible for maintaining effective audiometric records for each employee who in the absence of hearing protection regularly encounters noise at levels of 85 dB(A) or higher, and that such audiometric records be required to be keyed 1/ to social insurance numbers, 2/ to Miner's Certificate numbers where such have been assigned, and 3/ to a code number of noise-profile-encounter as previously recommended [Royal Commission Page 232]
	That the Occupational Health and Safety Branch commission on a five-year cycle statistical assessments of the state of hearing among sample populations of workers in mines, and that the first review be of production crews in underground operations, including diesel operators [Royal Commission Page 232]
	That the Occupational Health and Safety Branch regularly inspect all audiometric testing facilities not under the supervision of a designated medical specialist, and that any designated medical specialist be required to certify biennially in writing that the facilities under his supervision conform to the minimum standards of the Branch as then current [Royal Commission Page 233]
	That the Occupational Health and Safety Authority be assigned by statute the responsibility to establish standards or guidelines for personal exposure to all toxic substances and hazardous physical agents and that, subject to any statutory standards and in consultation with industry and labour, the Authority issue a code of practice for the application in mines and plants of the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists [Royal Commission Page 235]
	That the mining industry establish for its employees, where such is not now provided, occupational health surveillance by a supervising medical director or consultant experienced in occupational medicine [Royal Commission Page 237]
	That the labour unions individually or in consort appoint to their staff a consulting specialist in occupational medicine [Royal Commission Page 237]
1981	That wherever practical, fall-on protection be installed on all man-operated underground equipment. [Towards Safe Production Page 233]
	That a planned and systematic program of visual inspection of each active work area be conducted in each mine. [Towards Safe Production Page 234]
	That the inspections be carried out by persons who have specialized knowledge in rock mechanics. [Towards Safe Production Page 234]
	That these inspections be carried out under an auxiliary source of high intensity lighting. [Towards Safe Production Page 234]
	That the persons making these inspections be required to file regular written reports with the supervisor of the inspection program. [Towards Safe Production Page 234]
	That work crews lie formally and systematically made aware of ground conditions in the areas in which they are working. [Towards Safe Production Page 234]
	That inadequate lighting be investigated as a possible cause of all reportable underground accidents and that in all eases of serious underground accidents, photometric valves he recorded by persons trained in the use of photometric equipment. [Towards Safe Production Page 234]
	That Ontario mining companies and the unions representing workers in the mining industry seriously consider adoption of an approach to the management of alcohol and drug abuse in the workplace along the lines suggested. [Towards Safe Production Page 236]
1986	That auxiliary high-intensity lighting be available in all active work areas to assist in ground-control- related activities such as inspection and scaling. [Ground Control & Mine Rescue Page 64]
	That within one year of the release of this report lighting standards - as they relate to ground control and emergency preparedness - shall be

	established for use in all underground mines. [Ground Control & Mine Rescue Page 64]
	That Fall-On Protection shall be mandatory on all vehicles operating in areas requiring this type of protection. This recommendation shall be referred to the established FOPS sub-committee which will develop standards for its implementation. [Ground Control & Mine Rescue Page 69]
	That soft rock mining operations be considered separately from hard rock mining in setting standards related to ground control practices. [Ground Control & Mine Rescue Page 68]
1995	It is recommended that mines be required to develop and implement protocols for the setting, resetting, and the noting and acceptance of alarm conditions raised by any gas monitoring system in use at the mine. In particular, such protocols should define: who is authorized to set or change alarm levels and the recording of those settings or changes; who is responsible for the acknowledgment of alarms and recording of acknowledgments; who is responsible for communicating the occurrence of alarms and initiating action as a result of those alarms; and how the actions of responsible persons, and the identity of those persons, are to be recorded. [Moura Page 68]
	It is recommended that all mines be required to develop and implement a spontaneous combustion management plan along the lines outlined to provide effective long term control of that risk and which satisfies any requirements of the Chief Inspector of Coal Mines as a condition for continued operation of the mine. [Moura Page 62]
	In respect of the design, installation and maintenance of seals, the Inquiry recommends that: the location of final seals be subject to approval by the District Inspector of Mines; it be a requirement that seals be constructed using only materials that have been approved for the purpose by the Chief Inspector of Coal Mines; and the Chief Inspector of Coal Mines should determine and then apply requirements appropriate for the design and installation of seals and for their long-term stability. [Moura Page 69]
	The Inquiry recommends that minimum requirements provide for: the continuous and effective sampling and monitoring of the atmosphere in a sealed area including a minimum number of sampling points and suitable location(s); means whereby the pressure difference between the inside and outside surfaces of seals can be measured; the effective ventilation of the outside surfaces of seals; and regular inspection and periodic auditing on the long-term performance of seals and sealed areas. [Moura Page 69]
	It is for these reasons that the Inquiry further recommends that it be a requirement that no part of a mine be sealed without the prior written approval of the District Inspector of Mines (other than in an emergency, whereupon the inspector must be informed as soon as practicable thereafter). [Moura Page 69]
	It is further recommended that funds to be made available through the Queensland Government in order to obtain such a system, such that equipment for the inertisation of a coal mine or parts of a mine, with appropriately trained people and operating systems, be readily available for use in Queensland Coal Mines. This equipment should be maintained and operated by the Queensland Mines Rescue Service in a central location such that it can service all the mines in Queensland on a fee for service basis. [Moura Page 70]
1997	The overriding principle in mine ventilation must be that the mine is properly ventilated at all working times. It is the primary duty of the mine manager to ensure this proper ventilation: All active working places should be ventilated by a current of fresh air containing not less than 19.5 per cent by volume of oxygen and not more than 0.5 per cent by volume of carbon dioxide; and Each working face should receive fresh air of sufficient volume and velocity to dilute and render harmless all noxious or flammable gases and maintain all working and travelling areas in a safe and fit condition. [Westray Page 276]
	No mine should start up without a comprehensive ventilation plan approved by the regulator. The ventilation plan should be subject to at least an annual update, and any changes in the interim should be subject to approval by the regulator. [Westray Page 276]
	The ventilation plan should contain details of the system proposed, or of amendments to the existing approved system, and should indicate: the limits of the mine property and any adjacent workings, as well as any abnormal conditions; the location and detailed specifications of all surface fans and all surface openings; the direction, velocity, and volume of air at each mine opening; all underground workings, including location of all stoppings, overcasts, undercasts, regulators, doors, and seals; the method of sealing worked-out areas, provisions for air sampling behind any such seals, and the manner in which such sealed areas will be vented into return air passages (ensuring that no intake air is or could be passing any sealed-off area); the

	location of all splits and the volume of fresh air entering each split and of return air at each cross-cut in a room-and-pillar mine and at each working face; and the locations for the measurement of air in the mine to ensure the proper ventilation at all times. [Westray Page 276]
	The regulator may submit plans or amendments to a qualified mine ventilation engineer for review, and any fee for such review should be the responsibility of the mine operator. The regulator may require modifications to the plan in the interests of safety. [Westray Page 277]
	The regulator, in consultation with a qualified ventilation engineer, should draft regulations dealing with main fans and auxiliary fans. These regulations should include: details of the design, installation, operation, maintenance, and inspections of such fans; and requirements for instrumentation, the recording of data from such instrumentation, and the filing of this data with the regulator. [Westray Page 277]
	No booster fan should be installed underground without the approval of the regulator. [Westray Page 277]
	Every main ventilating fan should be mounted above ground in a fireproof fan house located at a safe distance from any mine opening and offset from any such openings or connections. The fan house should be equipped with a weak wall or explosion door located in a direct line with any possible explosion forces. Every main fan should be equipped with an audible alarm that sounds automatically if the fan stops or slows down. [Westray Page 277]
	Where any fan used in ventilating a mine stops for any reason, the area affected should be immediately evacuated. No auxiliary fan should be restarted until a qualified person has inspected the area and found it to be safe and free of gas. The area should not be re-entered until the ventilation has been restored to the required level and the area has been found to be safe and free of gas by a qualified person. If any fan remains stopped for more than 30 minutes, the mine operator should report the relevant circumstances to the regulator. [Westray Page 277]
	The regulator, in consultation with a qualified ventilation engineer, should draft regulations dealing with requirements for ducting, brattice, stoppings, locations of measuring devices, and sealing of abandoned sections of the mine. All brattice cloth, ducting, and materials used for constructing stoppings should be of fire-resistant material. [Westray Page 277]
	Equipment used to ventilate an underground coal mine should be of a type approved by the regulator and should be installed in an approved manner. Equipment, materials, or procedures not previously approved may be approved if the regulator is satisfied that the same measure of protection is provided to the underground worker. [Westray Page 277]
	Unless specifically approved in writing by the regulator, no more than one mechanized coal mining unit should operate in each ventilation split. Each split should be provided with a separate supply of fresh air. [Westray Page 278]
	Ventilating air should not be recirculated without the written consent of the regulator. [Westray Page 278]
	The mine operator should employ a qualified mine ventilation technician to be responsible for the operation and maintenance of the ventilation system. The ventilation technician should measure the airflow and sample the air quality in the mine at approved intervals of at least once a month for the whole mine and weekly for working areas. The results of ventilation and air quality tests should be recorded and a copy of such record should be filed with the regulator. [Westray Page 278]
	Workers should be removed from any area in a mine where the concentration of dust or noxious gases in the air exceeds the standards set out by the American Conference of Governmental Industrial Hygienists (ACGIH). [Westray Page 278]
	Devices used for testing air quality, velocity, and volume should be of a type certified and approved for such use by the Canada Centre for Mineral and Energy Technology (CANMET), the Approval and Certification Center of the Mine Safety and Health Administration (MSHA), the Canadian Standards Association (CSA), or other such equivalent testing body. [Westray Page 278]
	The level of methane in an air intake to the working face of the mine should not exceed 0.5 per cent by volume: If the methane level exceeds 0.5 per cent by volume, the ventilation technician or other qualified person must take steps to adjust the ventilation system to dilute the methane to acceptable levels; If the methane level in any part of a mine reaches or exceeds 2 per cent by volume, all workers must be evacuated from the affected area; The airflow throughout the mine, including the mine face, should be such that methane will be diluted to a level below 0.5 percent by volume, as measured at least 30 cm from the roof or ribs; The velocity of air throughout the mine should be sufficient to prevent the formation of methane layers. [Westray Page 313]

	The mine operator should provide suitable testing and calibrating facilities on the mine surface. Methanometers should be tested for accuracy before each shift and calibrated as required. [Westray Page 313]
	If the locked flame safety lamp is used at all, it should be handled only by persons who have received adequate training in its assembly and operation. No lamp should be reignited underground unless the methane content in the ambient air is 0 per cent, as determined by a methanometer. [Westray Page 313]
	If the methane level in the area reaches or exceeds 1 per cent by volume, any electrically operated equipment in use should be shut down, and any shot firing being carried out should be discontinued: In addition to other safety devices, any electrical equipment operating at the mine face or in reasonable proximity, as established by the regulator, should be equipped with a methane monitoring device capable of continually monitoring the methane content of the air; If the methane content exceeds 1 per cent by volume, the methane monitoring device should automatically shut down the electrical equipment; The electrical equipment should not be re-energized until a qualified person certifies that the methane content in the air has been diluted to a safe level. (30 CFR sets out this requirement as it applies to mines under the jurisdiction of the U.S. Mine Safety and Health Administration.); The methane monitors installed on electrical equipment should be kept operative at all times and tested weekly for accuracy. Sensors should be affixed to the equipment as close to the working face as practicable. [Westray Page 313]
	The operation of mobile diesel-powered equipment underground should be regulated to ensure that the health and safety of the workforce is not endangered or impaired by such operation. [Westray Page 314]
	The regulator may require, as part of the mine development plan, a plan for the installation of a remote system for monitoring the mine atmosphere, with appropriate audible alarms and recording devices. Such a monitoring plan should include the provision that a qualified person must be at the remote monitoring station at all times that the mine is operating. [Westray Page 314]
	Every mine development plan should include complete details of any program or process designed to drain methane from the coal seam before, during, and after mining. The regulator could waive this requirement if satisfied that the program or process would be impractical and that general mine safety would not be compromised. [Westray Page 314]
	Every coal mine operator should prepare a program for the regular clean- up and removal of coal dust and other combustibles from the floor, roof, and ribs of roadways and work areas in the mine. A copy of the program should be filed with the regulator, who may require changes in the clean-up program if it does not comply with accepted industry standards. [Westray Page 348]
	Sufficient water should be provided in the mine to ensure that an adequate supply is available to wet the coal being mined and transported within the mine: All coal-cutting picks should be equipped with water-spray jets of sufficient number and size to ensure that the areas of the coal face being worked are maintained in a damp condition so as to render any coal dust incombustible; and All transfer points where coal is moved from one mode of transport to another should be equipped with water-spray devices sufficient to render any coal dust incombustible. [Westray Page 349]
	All underground areas of a coal mine should be stonedusted to within 12 m of the working face and all cross-cuts less than 12 m distant from the face should be stonedusted. This would not apply to those areas within the mine containing sufficient moisture to render the coal dust incombustible or for which the regulator, after examination, has granted exemption. [Westray Page 349]
	A mine operator should file with the regulator a copy of the stonedusting program for the mine, including the method and frequency of testing; the type of testing equipment used; the type and number of dust-spreading machines used; the frequency of dusting; and the location and quantity of stonedust stored in the mine for emergencies (as opposed to normal usage). [Westray Page 350]
	The material used for stonedusting should be of a type approved by the regulator for that purpose and should meet accepted industry standards as to size, composition, and incombustibility. [Westray Page 350]
	Dust samples should be taken at least once a week using a method approved by the regulator for that purpose. Samples should be taken according to a regularly updated and approved plan. The regulator may require additional testing and may grant exemptions, providing that the overall safety of underground workers is not compromised. [Westray Page 350]
	The regulations should specify the following at a minimum: Ground control plans and any revisions to those plans should be prepared by the mine

	operator and submitted to the regulator for approval prior to the implementation of any such plans; The ground control plan should show the existing geological conditions and the mining system to be used. The plan should also indicate any unusual hazards and outline the manner in which these will be handled; Approved plans should be available to miners and other underground workers and should be posted in the mine at the area affected by the plan; and What the plan is required to specify should be set forth by the regulator from time to time, and should include: a columnar section of mine strata; planned width of openings and size of pillar (if required); thickness of seam; method of support to be used; type, sequence, and spacing of support materials; requirements for temporary roof support systems; and type and thickness of strata in the roof and in the floor for a depth of 3 m below the coal bed. The regulator may require further and better information on the plan and may require that the plan be reviewed by a qualified specialist in rock mechanics. The regulator may require revisions to the plan at any time if satisfied that conditions or accident experience indicate that such revisions are necessary or conducive to safety. The ground control plan should be reviewed at least once every six months by the regulator. The mine operator should record on the plan and report to the regulator any unplanned fall of roof or rib or any significant rock burst (more than 0.3 m in thickness) that occurs above the bolt anchorage area, impairs ventilation, impedes the passage of persons, causes injury to miners, causes miners' withdrawal from the area, or disrupts activities for more than one hour. All roof control materials should conform with standards as established by various testing agencies such as the Canadian Standards Association (CSA) or the American Society for Testing and Materials Specifications (ASTMS). In the absence of standards, such materials could be approved by the regulator. The regulator should from time to time issue directions, such as found in 30 CFR, respecting the use of roof bolts, torquing requirements for roof bolts, and testing requirements for roof bolts and for other types of roof support systems. All entries and drives where roof bolting is the main means of roof support should have imbedded warning devices that monitor any downward movement in the roof strata. Such warning devices should be of a type approved by the regulator and should be placed at intervals specified on the plan. Installation of such devices should not relieve the operator from making regular inspections as prescribed. (The type of device referred to here is that generic category in which the "tell-tale" extensometer — the simple mechanical gauge produced at the CANMET Coal Research Laboratory in Cape Breton — would be included.) [Westray Page 384]
	Each crew at the working face of a mine should include a person trained in the use of a methanometer. This person should carry, while in the mine, an approved device or devices capable of testing for both methane and oxygen, and capable of testing at the roof and in roof cavities for layering. [Westray Page 313]
	The mine operator should employ or retain the services of a qualified ventilation engineer to assist in the preparation of all ventilation plans or amendments to such plans. The ventilation engineer should sign any ventilation plans or amendments before they are submitted to the regulator. [Westray Page 277]
2006	Inspections of the construction of seals must be conducted by a certified engineer. The inspection must include monitoring the construction for a sufficient time, as well as evaluating the completed seal, to insure each seal is properly installed. The certified engineer should record the findings in an appropriate book. [Sago Page 8]
	The regulatory agencies should routinely inspect the seal during the construction and at the completion of each seal. Sufficient time for this inspection must be permitted to determine that all seals are properly constructed. [Sago Page 8]
	The use of Omega Blocks should not be permitted as a ventilation control in any underground mining operation. [Sago Page 8]
	The National Institute for Occupational Safety and Health (NIOSH) recently released a draft report entitled, “Explosive Pressure Design Criteria for New Seals in U.S. Coal Mines.” The UMWA fully endorses the report and its recommendations, as follows: For unmonitored seals where there is a possibility of methane-air detonation behind the seal, seals should be designed and built to withstand a pressure of 640 psi; For unmonitored seals with little likelihood of detonation, seals should be designed and built to withstand a pressure of 120 psi; For monitored seals where the amount of potentially explosive methane-air is strictly limited and controlled, seals should be designed and built to withstand a pressure of 50 psi, if monitoring can assure that the maximum length of explosive mix behind a seal does not exceed 15 feet and that the volume of the explosive mix does not exceed 40 percent of the total sealed volume. [Sago Page 8]
	The method of seal construction submitted by the operator in the ventilation plan and approved by the agencies must include: Seals must be hitched

	into the ribs and bottom a minimum of 6 inches; A method to continually monitor the atmosphere in by the seals from a remote location on the surface; Sealed areas must be treated as an integral part of the mine's overall ventilation system, and be specifically designed and approved for each installation at each mine. The seal requirements must be based on several factors, including area to be sealed, special conditions within the area to be sealed and methane liberation; and Seals must be constructed of solid, incombustible material as prescribed in the 1977 Mine Act. [Sago Page 8]
	The agencies should no longer permit areas of the mine that are sealed to self-inert without continuous monitoring as recommended by NIOSH. [Sago Page 8]
	Areas of the mine that are to be sealed must be free of all debris that is not permanently installed during the mining process. Materials and supplies such as unused roof support material, posts, oil and hydraulic containers, cables, equipment, belt structure, message or other cables and electrical components or cables must be retrieved and placed in a safe area outside the seals. [Sago Page 8]
	Seals in worked-out or abandoned areas of the mine should be visually inspected and tested each shift with an approved methane detector to insure their structural integrity and to check for methane leakage. [Sago Page 9]
	Seals that do not pass this inspection must be immediately leak-tested utilizing the same methodology currently used for this purpose at NIOSH's Lake Lynn experimental mine. Any leaks or damage to the seal must be repaired immediately. [Sago Page 9]
	Adequate rock dusting of the area prior to sealing must be required. Operators must be required to bulk dust each entry and crosscut prior to the start of the sealing process. The final seals should not be installed until the area is inspected and the agencies are satisfied the area has been sufficiently rock dusted. [Sago Page 9]
	The agencies should consider future sealing methods that require approval of smaller, more manageable areas of the mine. These smaller sequentially sealed areas will eliminate large areas where enormous volumes of explosive gases can accumulate, allowing better control within the area. Successively sealing these areas will afford additional protections to miners. [Sago Page 9]
	The agencies should not approve ventilation plans that utilize blowing ventilation where active working areas are in-by. [Sago Page 9]
	The practice of second mining should not be approved. [Sago Page 10]
	The Union calls for the immediate and permanent ban on the use of all Omega or similar-type blocks and material in any underground area of all coal mines. [Sago Page 10]
	MSHA should rescind its regulation that permits alternative materials and methods for constructing seals, and immediately require that all seals be explosion-proof seals or bulkheads, as is required by Section 303(y)(2) and (3) of the Federal Mine Safety and Health Act of 1977. [Sago Page 10]
	The Union believes the current protocol used for testing and approving seals is flawed. The National Institute of Occupational Safety and Health (NIOSH) recently issued a draft report entitled "Explosion Pressure Design Criteria for New Seals in U.S. Coal Mines." The report addresses two critical issues: What explosion pressures can develop during an explosion within a sealed area, and What are the appropriate design criteria for seals that will withstand these pressures? [Sago Page 10]
2011	Specifically use a "pattern of violation" and/or "flagrant violation" authority for violations of key standards designed to prevent explosions, and apply meaningful sanctions, such as revoking the operator's ventilation plan. If an operator's plan is revoked for reckless or repeated behaviour, he should be offered a brief period of time (e.g., five days) to make the safety case to MSHA as to why the mine's ventilation plan should not be revoked. [Upper Big Branch Page 109]
	A procedure should be adopted that would require mine operators repeatedly cited for failing to follow their own approved ventilation plan to notify MSHA and WVMHST when subsequent ventilation changes are completed and before miners are allowed back underground. Affected miners would be entitled to full compensation by the operator at their regular rates of pay and work schedule for the entire period they are idled. [Upper Big Branch Page 109]
	Each mine should be required to maintain and continuously update records of the amount of rock dust purchased and the amount used daily. Failure to maintain adequate records would result in a citation with a monetary fine. [Upper Big Branch Page 109]

	WVMHST and MSHA should undertake reorganization on their ventilation approval system to ensure that plans and requirements are known and understood by both the ventilation specialists as well as the inspectors. [Upper Big Branch Page 109]
	WVMHST, NIOSH, MSHA and the mining industry should adopt before the end of 2011 rules to: reduce the permissible exposure limit (PEL) for coal mine dust to 0.09 mg/m3; reduce the PEL for crystalline silica to 0.05 mg/m3; and mandate continuous dust monitoring, verification of mine operators' dust control plans at normal production (e.g., at least equal to the average production recorded for the most recent 30 production shifts), and single-shift sampling. [Upper Big Branch Page 113]
	Mechanized rock dusting must be conducted in all portions of underground mines, as well as the installation of "passive barriers" to help stop ignitions from turning into large explosions, such as occurred at Upper Big Branch. [Upper Big Branch Page 110]
2012	None
2015	The Ministry of Labour to require employers in the mining sector to conduct risk assessments, which would include measures and procedures to control the risks identified in the assessment as likely to expose a worker to injury and illness. The joint health and safety committee, health and safety representative, union or workers be consulted on the risk assessment. Employer risk reassessments are to be done as often as necessary to ensure programs that result from the assessment continue to protect workers. [Mining Review Page 29]
	The Ministry of Labour to require that mining employers to address the priority hazards identified in the risk ranking exercise: Enhance ground control protection by identifying key elements in the control of these hazards, and requiring employers to maintain a record of significant seismic events in addition to incidents of ground instability; Require employers to prepare a formal plan to manage hazards that cause occupational illness, including requirements for worker and supervisor training and communication; and Require all underground mines employers to have in place a formal water management program; Specify that precautions be taken by employers to guard against the accumulation of water in bins, ore and waste passes and chutes; and Require all underground mines to have in place a formal traffic management plan. [Mining Review Page 29-30]
	The Ministry of Labour to review existing occupational exposure limits for a number of key airborne and chemical hazardous substances in underground mines with a view for giving further consideration to the limits for those substances and, if appropriate and advisable, amend Regulation 833. Priority to be given to a review of the occupational exposure limits for silica, nitrogen dioxide and diesel particulate matter (DPM). Other hazards to be considered include: sulfur dioxide, and radon. [Mining Review Page 30]
	The Ministry of Labour, supported by all relevant health and safety system partners and subject matter experts, to undertake a Mining Sector Risk Assessment with employers and labour every 3 years. [Mining Review Page 28]

APPENDIX 3C

Table 3.6 Recommendations relating to training, education and competence

1967	Present managers and surveyors should as soon as possible receive training in ground-water conditions and the rudiments of soil mechanics so as to be able to appreciate the significance of the reports of, and opinions expressed by, the experts in these subjects. The statutory qualifications for managers and surveyors should in future include awareness of the elements of soil mechanics and hydrogeology, in addition to the geology which is already comprised in the syllabus. The Unit Mechanical Engineer and charge hand should be instructed in the significance of tip deformation and of the appearance or disappearance of water-courses. In addition, the charge hand should be trained to record at frequent intervals on a pro-forma a simple questionnaire dealing with such matters as toe-movement, crest-sinking, cracks and breaks. These records should be kept at the Unit Office and inspected regularly by the manager and mechanical engineer. They should also be produced to the civil engineer charged with tip responsibility and to Her Majesty's Inspectors of Mines on the occasion of each visit to the tip. [Aberfan Page 128]
	Professor Bishop further recommended that, in order to ensure that only suitably qualified engineers are employed for site investigation, a Panel of Approved Engineers should be established on lines similar to those set up under the Reservoirs (Safety Provisions) Act, 1930, as amplified in a Report on Reservoir Safety by the Institution of Civil Engineers in 1966. We place on record this latter representation, but we do not ourselves either endorse or reject it. We had described to us a little of the operation of the 1930 Act, but not enough to justify us in inviting Ministers to follow it as a precedent; indeed, we were told that the Act requires amendment in a number of respects and that the 1966 Report just referred to contains provisions for its revision. [Aberfan Page 126]
1976	That engineering schools review and redefine their responsibility to the profession to ensure that graduates are more keenly aware of and responsive to the impact of technological design upon the occupational health and safety of workers [Royal Commission Page 205]
	That profiles of risk-encounter for toxic substances be developed by examining the work patterns of maintenance workers, and that modular training be adapted to such profiles [Royal Commission Page 206]
	That the core of the staff of the Mines Inspection Branch continue to be based on persons of exceptional professional experience in mining, and related fields of engineering, supplemented by special training in occupational health and safety and in the principles of the administration of work [Royal Commission Page 163]
	That the industry, government, and labour give high priority to the development, standardization, and accreditation of modular training and qualification for workers in mines and plants [Royal Commission Page 169]
	That resources for joint research and teaching by specialists in occupational health and safety in faculties of medicine and engineering be given high priority by both the universities and government [Royal Commission Page 205]
1981	That upon implementation of the modular training program in specialized skills for underground miners, a modular training program for surface operations be developed. [Towards Safe Production Page 235]
	That the Mines Accident Prevention Association of Ontario investigate and develop appropriate screening tests for prospective underground miners and make these available to the industry. [Towards Safe Production Page 235]
	That the common core modular training program be augmented by a formal program of on-the-job training leading to full production capability. [Towards Safe Production Page 235]
	That each mining company undertake a comprehensive audit of the skills of its underground miners with a view to using modular training to upgrade skills. [Towards Safe Production Page 235]
	That joint training tor members of joint health and safety committees be undertaken and where possible, supervisors also be involved. [Towards Safe Production Page 229]
	That, in the absence of agreement to the contrary, the costs of such programs be charged back to the company or union on a per participant basis. [Towards Safe Production Page 230]

	That the allocation of government monies to health and safety training be on condition that joint training be carried out wherever possible. [Towards Safe Production Page 230]
	That first line supervisors receive the requisite training and carry out workplace safety inspections as pan of a planned program of rotation of first line supervisors through the safety department. [Towards Safe Production Page 231]
	That branch inspectors be given the training necessary to carry out these responsibilities. [Towards Safe Production Page 232]
	That the future recruitment of branch engineers be based in part upon interpersonal skills and the potential to act in a meditative mode, and that the training and development of branch engineers include these aspects. [Towards Safe Production Page 233]
	That each mining company operating in Ontario employ at least one professional engineer with post-graduate qualification in rock mechanics and that a person holding such qualification be used in the design and planning of a mine or mine expansion and that a person holding such qualification be made responsible for the company's ground control program. [Towards Safe Production Page 233]
	That a committee be struck, with representatives of the mining companies, the unions representing workers in mines and mining plants and the government, for the purpose of developing a modular training program for first line supervisors in both underground and surface operations and that individuals be certified by the company conducting the program as competent to supervise in a mine or mining plant upon successful completion. [Towards Safe Production Page 227]
	That from the date the program commences, only persons who have such certification be appointed to fill regular first line supervisory positions. [Towards Safe Production Page 227]
	That persons occupying first line supervisory positions as of the date the program commences, be required to complete the program and become certified within a reasonable lime period stipulated by the tripartite committee. [Towards Safe Production Page 227]
1986	That a separate section on ground control be added to the skills included in the Common Core training for new underground miners. [Ground Control & Mine Rescue Page 52]
	That the present tripartite committee established to approve modular training programs shall expand those programs to include specialist modules on ground control for all underground miners. [Ground Control & Mine Rescue Page 52]
	That all miners receive periodic refresher courses in ground control if required. Labour shall be encouraged to participate in the development of the curriculum. [Ground Control & Mine Rescue Page 52]
	That miners who have been off the job for one year or more should be evaluated with respect to their knowledge of current ground control practices, and should receive appropriate training where necessary before they return to regular underground work. [Ground Control & Mine Rescue Page 52]
	That non-miners working underground be trained in the fundamentals of ground control, including the recognition of potential hazards. [Ground Control & Mine Rescue Page 53]
	That all mining supervisory staff receive adequate training in ground control. The ground control module for supervisors being developed by the tripartite committee on modular training shall be deemed adequate for this purpose. [Ground Control & Mine Rescue Page 53]
	That health and safety committee members shall receive the same training in ground control as supervisory staff. [Ground Control & Mine Rescue Page 53]
	That colleges and universities training mining engineers recognize that good undergraduate teaching in a subject such as rock mechanics demands lecturers who have a deep understanding of the subject, solid practical experience in its application in real mining situations, and the ability to present their material in clear and simple terms which will enable the students to apply their knowledge to the solution of the problems they will encounter in the industry. [Ground Control & Mine Rescue Page 55]
	That the teaching staff in colleges and universities with rock mechanics programs shall have strong practical experience in underground hard rock mining. [Ground Control & Mine Rescue Page 55]
	That qualified personnel from the mining industry participate in teaching graduate and undergraduate programs at colleges and universities with rock

	mechanics programs. [Ground Control & Mine Rescue Page 55]
	That additional funding be made available to colleges and universities to provide the improved facilities and instruction necessary to permit adequate training in ground control. [Ground Control & Mine Rescue Page 545]
	That the mining industry shall establish a special chair in ground control at an Ontario university to improve the standard of teaching in rock mechanics for graduate and undergraduate students, and to conduct research projects directly related to the mining industry. This chair shall be closely identified with the Ontario mining industry, and shall take direction from the industry. [Ground Control & Mine Rescue Page 55]
	That instruction in ground control be integrated into the undergraduate programs in mining engineering. The Rock Mechanics and Strata Control Committee of the Canadian Institute of Mining and Metallurgy shall be asked to effect this change through the organization of a National Forum on mining-related ground control education. [Ground Control & Mine Rescue Page 56]
	That community colleges and universities offering mining programs be encouraged to develop additional short courses in ground control, targeted to specific groups in the mining industry. [Ground Control & Mine Rescue Page 56]
	That the mining industry in Ontario be encouraged to sponsor their employees' attendance at existing short courses and other programs as they become available. [Ground Control & Mine Rescue Page 56]
	That these short courses be designed so that adequate training can be given in various locations, including remote regions of the province. [Ground Control & Mine Rescue Page 56]
	That certification courses be developed in practical ground control for practising ground control engineers and other technical personnel. [Ground Control & Mine Rescue Page 56]
	That the mining industry be encouraged to sponsor qualified employees who seek post-graduate degrees in rock mechanics. [Ground Control & Mine Rescue Page 56]
	That worker-inspectors, where they exist, be given the same training in ground control as that recommended for supervisory staff elsewhere in this report. [Ground Control & Mine Rescue Page 69]
	That the Workers' Compensation Board re-evaluate the qualifications required for mine first-aid attendants. [Ground Control & Mine Rescue Page 63]
	That all underground workers be encouraged to take first aid training, and to keep their training current. [Ground Control & Mine Rescue Page 63]
	That the necessary additional training in non-fire emergencies be developed by a tripartite committee consisting of representatives of mine management, unions, and government. [Ground Control & Mine Rescue Page 63]
	That the Ministry of Labour, through training and recruitment, ensure that its ground control staff be at a world-class level in their discipline, and have the credibility to relate effectively to the international ground control community. [Ground Control & Mine Rescue Page 68]
	That Ministry of Labour inspectors be provided with such additional training as may be required to enable them to deal effectively with site-specific ground control problems. [Ground Control & Mine Rescue Page 69]
1995	It is recommended that all employees be effectively trained to: recognize indicators of specific mine hazards, such as spontaneous combustion, and their control; and become sufficiently familiar with mine gases, and associated risks. [Moura Page 64]
	It is further recommended that all persons holding statutory appointments, including inspectors must undertake: training in communications by completing an approved training course that deals will all aspects of communications; and completion of a retraining course each year, progressively covering and periodically revisiting mine gases, spontaneous combustion, mine fires, emergency procedures and communications, as they impact on the mine where they are employed, or over which they have jurisdiction. [Moura Page 64]
	It is recommended therefore, that the procedures for granting statutory certificates for underground coal mining and the conditions under which they are awarded, be reviewed. [Moura Page 64]
	In particular, it is recommended that certificates not be granted for life and that a system needs to be developed and put into effect as soon as practicable that requires certificate holders to demonstrate their fitness to retain the certificate of competency on a regular basis, at intervals of not less

	than three and not more than five years. [Moura Page 64]
	In particular it recommends that: the handbooks on spontaneous combustion, commonly referred to as the red and blue books, be revised, updated and republished for education and training use, particularly at colliery level; a supply of the handbooks be maintained with provision of periodical review of content for updating; appropriate audio-visual aids be produced for education and training purposes, particularly at colliery level; and as part of their safety training facilities, coal mines establish a reserved area accommodating a basic library of safety literature and other learning materials available for mine officials and mineworkers to consult at any time. [Moura Page 72]
	We recommend, therefore, that to be accredited as satisfying the academic pre-requisites for the granting of manager's, undermanager's, and deputy's certificates of competency in coal mining, all courses of instruction be required to include adequate instruction on spontaneous combustion (its nature, cause, detection and management) using appropriate supporting literature, case study material and other learning aids. [Moura Page 73]
	It is recommended that a position of ventilation officer be established as a statutory position at all underground coal mines. The ventilation officer appointed must have demonstrated competencies appropriate to the duties and responsibilities of the position and would be directly responsible to the mine manager for the planning, design and implementation of the mine ventilation system and for the establishment of effective standards of ventilation for the mine, methods for its control and protection, monitoring of performance, reporting procedures, maintenance of ventilation records and plans, and emergency action plans. [Moura Page 65]
1997	One regulatory organization (such as the Department of Labour or a board of examiners) should be responsible for certifying workers in underground coal mines in Nova Scotia. [Westray Page 132]
	Before approving the start-up of any underground coal mine, the regulator should review and amend the standards of certification to ensure the following: Standards of certification fit the mining methods and technology of the proposed mine; All positions in the mining operation are filled by people with the qualifications and experience necessary to do their jobs safely; The system of certification applies to every person required to work underground. Categories of certification should include (at a minimum) coal miner, electrical tradesperson, mechanical tradesperson, surveyor, engineer, mine rescue person, and the various levels of supervisors and managers; Trainers have the necessary qualifications and experience. [Westray Page 132]
	The regulator should establish a model curriculum consistent with established standards and practices in the coal mining industry. [Westray Page 132]
	The mine operator should be required to have in place a training program, approved by the regulator, for every position in the workplace. The mine operator's training proposal must: conform to or be more rigorous than the model curriculum; show when, how, and what training will be done; incorporate annual refresher training and safety education; provide for adequate orientation to the mine for all new employees, including those with experience in coal mines; and include complete and sufficient training for operators of individual pieces of mining equipment prior to their being assigned operating positions. [Westray Page 133]
	The mine operator should be required to keep training and work history records for applicants for certification. The regulator should: check applicants' records, making sure that training is taking place; and test applicants for certification in a manner that establishes whether underground workers are trained sufficiently to work safely. [Westray Page 133]
	The mine's joint occupational health and safety committee should periodically review training standards, policies, and programs to make sure that they adequately reflect changing technology and mining conditions and practice within the mine. [Westray Page 133]
	No provisional mining certificates should be issued in any circumstance. The process of granting certification based on status in other jurisdictions must be refined to ensure that qualifications are consistent with provincial requirements. The burden should be on the applicant to establish that his or her qualifications are sufficient to support the requirements for the certification sought. Any person granted certification based on status in another jurisdiction should be required to be examined in Nova Scotia for such certification at the earliest reasonable time. [Westray Page 87]
	The legislation and regulations governing coal mines should be reviewed to ensure that all personnel working underground receive training in ground control as appropriate to their activities and responsibilities. In particular: Coal miners should receive a course on ground control as part of their basic mine training, plus annual refresher courses on ground control; Mining supervisory staff, including mine managers, underground managers, and

	overmen, should receive extensive training in ground control; Non-mining personnel employed underground should receive sufficient training in ground control to enable them to recognize potential hazards; Training programs for these three categories of employee should be developed by mine management in cooperation with the joint occupational health and safety committee and the regulator. The regulator should review these training programs to ensure that they reflect changing technology and mining practices. [Westray Page 385]
	If it is decided to pattern the Nova Scotia coal mine regulation regime after that of the United Kingdom, all mine inspectors should have at least a degree in mining engineering, with some specialist training in both rock mechanics and ventilation relating to underground coal mining. If the U.S. Mine Safety and Health Administration approach is adopted, all mine inspectors should receive adequate initial training. In either case, all mine inspectors should be required to take periodic training, of at least one week per year, at an institute specializing in mine inspection and safety. [Westray Page 543]
	Labour and management should work together to educate and regulate the underground miner with a view to eradicating the practice of smoking in the coal mining environment. The following requirements should apply: Tobacco smoking and the possession of smoking materials and lighters by any person underground should be grounds for immediate dismissal from employment, the reason for dismissal to be recorded in the employee's record. Proof of tobacco smoking underground or possession of smoking materials underground should provide sufficient grounds for dismissing any grievance taken by an employee for unjust dismissal, and any arbitrator should be prohibited from substituting any other penalty in lieu of dismissal. Labour and management, with the cooperation of the Department of Labour, should investigate the feasibility of acquiring tobacco detection devices that would monitor miners entering the mine. [Westray Page 545]
	A legislative review committee should be established to review periodically the underground coal mine regulations to ensure that the regulations reflect current technology and that the use of such technology is consistent with mine safety. The committee should have the power to engage mining consultants with specific expertise consonant with the technical matters being considered. This committee could be modelled after the Mining Legislative Review Committee of the province of Ontario and should contain representation from the provincial departments involved in the planning and regulation of underground coal mines. [Westray Page 540]
2006	Training for SCSR donning and escape must be wholly separate from all other types of training miners currently receive. This training must be repeated every 90 days. [Sago Page 12]
	SCSR and escape training must be done in actual conditions underground and, to the extent possible, reflect real-life emergency situations. Miners must don the SCSR training model and walk at least a portion of the escape way. [Sago Page 12]
	Training for mine rescue teams should be required frequently, but at least every quarter (three months). Training should be done at each mine the rescue team is charged with covering. This will require surface as well as underground exercises to ensure the team members are familiar with the facility. [Sago Page 16]
	Mine rescue teams should be certified by MSHA to ensure competence. Certification should be directly tied to the team's demonstrating proficiency and skill in all aspects of mine rescue. Teams that do not pass the certification may continue to practice, but shall not be permitted to perform any actual mine rescue. [Sago Page 16]
	Training of all miners who work on seal construction must be given by a certified person with knowledge of why each construction requirement is necessary to the process. All information in the approved plan must be passed on during the training session. [Sago Page 8]
	"Tailgate" or descriptive training cannot be permitted for these types of tasks. Training must be comprehensive and clear. The trainer and trainee(s) must also be required to sign documentation that proper training was completed. [Sago Page 8]
	MSHA must immediately hire and train a sufficient number of inspectors to fill vacant positions and better prepare for the retirement of its aging workforce. [Sago Page 17]
	Training for SCSR donning and escape must be wholly separate from all other types of training miners currently receive. This training must be repeated every 90 days. [Sago Page 12]
2011	SCSR training should be realistic and conducted in actual mining situations, such as riding in a man trip and working on a longwall. It should

	incorporate a variety of actual in-mine scenarios for which the SCSR must be donned and activated. The training should emphasize the importance of activating the SCSR at the very first warning of an emergency. [Upper Big Branch Page 113]
	SCRS training should be conducted quarterly, instead of annually. [Upper Big Branch Page 113]
	MSHA, WVMHST and NIOSH should develop a program to measure and evaluate the effective- ness of training provided by certified trainers. [Upper Big Branch Page 113]
	The West Virginia Office of Miner's Health Safety and Training should re-double its efforts to ensure that all examiners are trained, and tested as many times as necessary, including in-mine demonstrations of their skills, to ensure the examiners understand their duties and perform them as they should be performed. [Upper Big Branch Page 110]
	The West Virginia Office of Miners' Health, Safety and Training should focus training efforts on those mines in which operators are found to be lax on safety training. MSHA and the state should have the authority to revoke the licenses of habitual offenders, for those who falsify records and for flagrant violations. [Upper Big Branch Page 110-111]
	MSHA and the State agency should provide annual training to miners on their statutory rights under the Mine Act and applicable state mine safety laws. This curriculum should outline the benefits of designating a miners' representative. [Upper Big Branch Page 111]
	Digital photographs from recent inspections and other appropriate visual aids should be used to demonstrate to miners, managers and inspectors acceptable and non-acceptable mining equipment and conditions. [Upper Big Branch Page 111]
	Federal and state agencies should undertake an aggressive campaign to undermine the "safety myths" or inaccuracies that emerged during the UBB investigation. Agencies should dispel these inaccuracies on federal and state agency websites and incorporate "myth busters" into miners' training. A few examples of the inaccuracies that emerged during interviews with miners and bosses include: a proper air velocity reading can be taken instantaneously; a CH4 monitor on a mining machine can be disconnected if it is defective or keeps alarming, and the operator is allowed to run coal for up to 24 hours while waiting for a new monitor to be installed; a miner should not don an SCSR until he knows it's really an emergency or when a boss tells him to don it; a miner can make a run by himself, without a CH4 detector, because only a boss can be certified to carry a spotter; red hat miners can be left by them- selves while a boss goes ahead of them to check for hazardous conditions. [Upper Big Branch Page 111]
2012	The regulator should supervise the granting of mining qualifications to mining managers and workers: The regulator should lead the work to strengthen standards so that they are comparable with those of Australia; The regulator should work with Australian counterparts towards developing a joint accreditation process with Australia and an Australia/New Zealand board of examiners; Additional statutory roles and qualifications are required in new regulations, including a statutory ventilation officer and an agreed level of industry training and supervision for all new or inexperienced workers; The regulator should work with the Accident Compensation Corporation and others on raising the standards of health and safety consultants. [Pike River II Page 341-342]
	Managers in underground coal mines should be appropriately trained in health and safety. [Pike River II Page 331]
2015	Enhance supervisor and management training by: Requiring the Mining Tripartite Committee, which supports the development of Common Core training, to present to the Ministries of Labour and Training, Colleges and Universities options and recommendations to enhance supervisor and management health and safety training; and Requesting the Mining Tripartite Committee to review the pre-requisites for Supervisor Common Core training and determining the best format for this training (e.g. classroom learning, hands-on experience). [Mining Review Page 47]
	The Ministry of Labour to engage in discussions with the Ministry of Training, Colleges and Universities about the quality and consistency of Common Core training delivery in the underground mining sector, evaluate the current state of that training, and identify circumstances where refresher training may be appropriate. [Mining Review Page 47]
	The Ministry of Labour and its partners to review the health and safety system's ability to meet the needs of the mining sector especially related to providing services to remote communities, training small numbers of trainees, and aligning their training activities to the priority hazards. Take appropriate actions based upon the findings of that review. [Mining Review Page 54]

APPENDIX 3D

Table 3.7 Recommendations relating to emergency management and mine rescue

1967	None
1976	None
1981	That the Mines Accident Prevention Association of Ontario sever its ties with the Ontario Mining Association, retain the services of a full-time executive director, establish its own offices separate and apart from the Ontario Mining Association offices, make provision tor its own support staff and services, and continue to be financed by levies against its member companies. [Towards Safe Production Page 231]
	That the Mines Accident Prevention Association of Ontario establish labour-management advisory committees at both the provincial and regional levels and that it moves to include representatives of labour and the public on its board of directors. [Towards Safe Production Page 232]
	That the Ministry of Labour, in consultation with management, labour and the Mines Accident & Prevention Association of Ontario, determine the specific information required to maintain an occupational accident data base for mines and mining plants which satisfies the prerequisites identified, and provide the Occupational Health and Safety Division of the Ministry with the resources and expertise necessary to collect this information, analyze and disseminate it. [Towards Safe Production Page 237]
1986	That the current mine rescue organization be expanded to handle all underground emergencies. [Ground Control & Mine Rescue Page 63]
	That a tripartite committee also be established to advise on all aspects of mine rescue equipment and emergency warning systems. [Ground Control & Mine Rescue Page 63]
	That mine rescue personnel suffer no loss of income as a result of injuries arising from mine rescue activities. [Ground Control & Mine Rescue Page 63]
	That the Ministry of Labour mine rescue organization be responsible for identifying and introducing specialized equipment needed for use in non-fire emergencies, and for developing or finding sources for such equipment. [Ground Control & Mine Rescue Page 63]
	That manway sizes, escape routes and refuge stations be sufficient to accommodate rescue operations. [Ground Control & Mine Rescue Page 63]
1995	It is recommended that mines be required to put in place Mine Safety Management Plans to cater for key risk areas. [Moura Page 62]
	It is further recommended that Mine Safety Management Plans be based on detailed risk/hazard analyses. [Moura Page 62]
	It is, therefore, recommended that a representative industry working party, containing appropriate expertise, be convened by the Chief Inspector of Coal Mines and that group be charged with the development of guidelines for the industry covering life support for escape. [Moura Page 66]
	Accordingly, it is recommended that the Chief Inspector of Coal Mines set up a working party, comprising persons with appropriate knowledge and experience, to examine and report on a range of issues relating to emergency escape facilities. [Moura Page 67]
	The Inquiry recommends that underground mines develop a surface area plan showing the location of mine entries, ventilation fan(s), access roads, surface installations, administration buildings and other infrastructure. Copies of the plan should be provided to the Chief Inspector of Coal Mines and lodged with the mines rescue brigade and local police station. [Moura Page 72]
	It is further recommended that both new and existing mines make provision for the rapid sealing of the mine from the surface through the installation of an air lock facility in at least one of the mine intakes for ready access to re-enter the mine. The plan should also indicate the location of any surface boreholes that may facilitate the monitoring of the underground atmosphere. [Moura Page 72]
	It is recommended that mines be required to develop and implement protocols, as a statutory requirement, for the withdrawal of persons when conditions warrant such action. [Moura Page 70]
	It is recommended that the Chief Inspector of Coal Mines convene an appropriate industry working party to develop guidelines for the use, in turn, of mines in the development of protocols for the withdrawal of persons. Developed and implemented protocols should be required to conform with the guidelines. [Moura Page 70]
1997	Every mine operator, indeed, every industrial plant or facility, should have a well-defined and comprehensive emergency procedures manual

	containing a complete and up-to-date list of all persons involved in any emergency operation. This list should contain an organization chart listing the individuals and their respective tasks, and a current telephone listing for each person. The manual should be prepared by the company in consultation with both the joint occupational health and safety committee and the safety coordinators with the appropriate government departments. The manual should set out, in detail, the quantity and location of all emergency supplies and equipment and the details of the deployment of these materials. A current copy of any such approved emergency procedures manual should be filed with the director of occupational health and safety, and copies should be provided to each person assigned any duty under the manual. [Westray Page 560]
	The Department of Labour, in consultation with the operator, should establish such rules and regulations that would ensure the department a full and active role in every mine-related emergency procedure or rescue operation in the province. The rules and regulations should set out the duties and responsibilities of each department inspector or safety examiner in any mine-related emergency or rescue operation. [Westray Page 561]
	Rescue and emergency equipment should be standardized so that those persons trained in rescue procedures will be completely familiar with the equipment available. Similarly, the various testing devices should be standardized so that the rescuers are able to use these devices without losing valuable time and without the danger of mistaken or inaccurate readings. [Westray Page 561]
	Every community at or near which underground mining operations are carried out should have a plan to provide emergency medical, fire, and other support services. The plan should include providing emergency training to the appropriate people in those communities. Some familiarity with the underground environment could be helpful in the event of a disaster. [Westray Page 561]
	Mine-rescue competitions, long a fixture in the underground mining industry, provide a valuable training incentive for miners. These competitions should be continued. [Westray Page 561]
2006	Mine ventilation systems must be designed to offer miners the greatest possible protection to enhance their ability to escape. Air used to ventilate seals must be coursed away from working sections, and immediately to the return. This is necessary to ensure that the integrity of the intake escape ways are not compromised. [Sago Page 11]
	All man doors must be clearly marked on both sides. [Sago Page 11]
	Steps must be taken immediately to significantly increase the number of qualified mine rescue teams nationwide. [Sago Page 16]
	MSHA should immediately require all mine operators to have two rescue teams readily available at all times when miners are underground. These teams should be made up of miners working at the operation who are familiar with the mine layout and conditions and those team members must perform all required training together. [Sago Page 16]
	All mine rescue teams should be required to participate in at least two mine rescue contests every year. Failure to participate must result in the team's certification being revoked. [Sago Page 16]
	Composite and contract mine rescue teams should not be permitted under any circumstances. [Sago Page 16]
	A member of the mine rescue team actively working in a mine or acting as backup should be immediately available when requested in the command center. [Sago Page 16]
	Additional oxygen devices must be readily available where miners are working to ensure there is an adequate supply to begin an escape in an emergency situation. Oxygen must be available for all miners to effectively escape from the deepest penetration of the mine to the surface. [Sago Page 11]
	Additional oxygen devices in protective cases must be stored at strategic locations in both the primary and secondary escape ways for miners to access as they travel out of the mine. These caches must be placed at a distance not to exceed 30 minutes normal walking distance. [Sago Page 11-12]
	Flame-resistant directional reflective lifelines must intersect every oxygen storage location in the escape way. [Sago Page 12]
	SCSR storage caches should include a communication system to the surface, first aid supplies and tethers as well as oxygen. [Sago Page 12]
	SCSRs currently deployed in the nation's coal mines must be immediately subjected to random testing to ensure they are working effectively. MSHA, with the assistance of NIOSH, should immediately begin a random testing of all units currently deployed in the field. [Sago Page 12]

	MSHA, with the assistance of NIOSH, should conduct a mandatory random sampling of all SCSRs deployed in the field annually. The annual sample size should be no less than three percent of all units deployed in the industry. [Sago Page 12]
	The cost of SCSR replacement units selected for testing must be borne by the mine operator as a normal cost of business. [Sago Page 12]
	The test protocol for approval of SCSRs must be re-evaluated and changed to ensure the adequacy and duration of the units. Testing of devices must take into consideration the temperature, age or other condition that may affect the unit's performance [Sago Page 12]
	Shelf life of stored and carried SCSRs must be re-evaluated and if necessary shortened, so that each unit can be relied upon to perform in an emergency. [Sago Page 12]
	New SCSRs should be positive-pressure units with full face masks. [Sago Page 12]
	Mine management must be required to contact the proper regulatory authorities and the mine rescue teams for their operation immediately, but at least within 15 minutes of the onset of the emergency. The operator should have enough responsible people physically on the mine site or immediately available by phone to handle these duties without delay. [Sago Page 14]
	MSHA must create a Mine Emergency Response Office (MERO) within the Agency. The MERO must be staffed 24 hours a day, seven days a week, by experienced full-time MSHA employees with extensive mining knowledge. Emergency contact to MSHA by mine management personnel should be available using a toll-free phone number. [Sago Page 14]
	The federal and state agencies should be responsible for immediately notifying and deploying all government rescue personnel, equipment and other necessary assets to the mine site after being notified that an emergency situation exists. [Sago Page 14]
	Every effort should be made to coordinate the emergency response of the federal, state and local agencies. [Sago Page 14]
	Mine rescue teams required to be first responders must be notified immediately, but at least within 15 minutes of the onset of an emergency. This notice should be made by mine management personnel immediately after notifying the regulatory agency. [Sago Page 14]
	Mine management must ensure that appropriate arrangements have been made to guarantee their designated mine rescue teams are available 24 hours a day, seven days a week, to cover any situation that may require their services. [Sago Page 14]
	Two (2) mine rescue teams designated as first responders must be employees of the mining company who routinely train together at the affected mine, but under no circumstance less than four times per year. These teams must be readily available at all times when miners are underground. [Sago Page 14]
	MSHA and NIOSH must update and test new, easily deployable, reliable and accurate seismic- type devices to locate trapped miners. At least one of these devices should be maintained in each MSHA District office. [Sago Page 13]
	"Safety chambers" and "safe havens" should be required in all mining operations. The Union notes that these are two distinct systems and they cannot be used interchangeably. [Sago Page 13]
	MSHA must take immediate control of all aspects of the rescue and recovery. It must create plans and implement them to facilitate the immediate use of all mine rescue assets as soon as possible. MSHA should exercise the authority mandated by Congress and not delay before implementing a plan to safely enter the mine and facilitate rescue activity. [Sago Page 15]
	Flame-resistant reflective directional lifelines must be required from the face areas in both the primary and secondary escape ways. These lifelines should direct miners from their workplace to the nearest surface escape, shaft, slope or capsule. [Sago Page 11]
	Tethers for linking miners together when necessary during escape should be available in every section at the in-by end of the lifeline. They should be of sufficient length to eliminate the possibility that miners will become entangled while they are walking or crawling to safety. Additional tethers should be located at strategic locations throughout the mine. [Sago Page 11]
	All mobile equipment entering the mine during rescue and recovery efforts must be equipped with two- way communications. [Sago Page 15]
	All evidence or materials that may become part of the official investigation must be secured immediately by MSHA. [Sago Page 15]
	MSHA must establish a rigid chain of custody for all evidence and see that it is followed to ensure accurate and credible results are obtained during

	testing procedures. [Sago Page 15]
	Representatives of the miners must be afforded full rights to participate in all aspects of the rescue and recovery operations and the subsequent accident investigation. [Sago Page 15]
	The mine operator must be on-site to provide logistical and general mine information necessary to facilitate rescue and recovery operations. [Sago Page 15]
	The federal and state regulatory agencies must secure the surface area of the mine and limit access by individuals who have no right to enter the property or are not involved in the rescue efforts. This will ensure rescue teams, fire crews, police, miners' representatives and other necessary personnel understand their roles in the disaster response and are not delayed in beginning the rescue effort. [Sago Page 15]
	Communications with family members, the press and general public should be handled by an independent arm of the federal government, much like the National Transportation Safety Board (NTSB) and Surface Transportation Board (STB) do with air, rail or highway incidents. They should also make necessary arrangements for family members as they arrive at the site. These requirements should be specifically laid out in the mine emergency response plan. [Sago Page 15]
	Information from the command center to any sources not immediately involved in the rescue efforts should be carefully monitored and verified to ensure accuracy. In the event miscommunications occur, they must be immediately corrected. [Sago Page 15]
2011	The mining industry, MSHA, and West Virginia should adopt the National Incident Management System (NIMS) Incident Command Model, a nationally recognized emergency incident management system, to improve coordination, cooperation and communication between public and private entities. [Upper Big Branch Page 112]
	Protocols should be established and followed with regard to mine rescue and recovery, using lessons learned and best practices identified from other emergency response events. [Upper Big Branch Page 112]
	The one-to-one backup system for mine rescue personnel, which is already established protocol, is absolutely critical for the safety of these volunteers. [Upper Big Branch Page 112]
	The mine rescue community should convene a summit of mine rescue team members, in particular, individuals who responded to the mine emergency incidents from 2006 to the present, to discuss the state of the U.S. mine rescue system. Advisory guidelines should be written for mine rescue teams. [Upper Big Branch Page 112]
	MSHA and West Virginia should require a digital recording of the activities and communications in a mine emergency command center. Briefings and debriefings of mine rescue team personnel also should be recorded. The current paper and pencil method fails to produce a thorough record of key data and decision points. Such a record is necessary to conduct a thorough investigation, assess the effectiveness of existing mine rescue operations and contribute to training curriculum for advanced mine rescue personnel. [Upper Big Branch Page 112]
	Mine operators' emergency response plans (ERPs) must be treated more than just more paperwork. ERPs should be developed collaboratively with miners, their families, local responders, and mine rescue team members, and revised based on mine-specific drills and table-top exercises. [Upper Big Branch Page 112]
	The U. S. Department of Labor should adopt a public investigation process for major mine disasters. Procedures should be established to provide for public hearings, including interviews of witnesses. [Upper Big Branch Page 112]
	If the investigations continue to be under the MSHA's direction, the agency should have subpoena power to compel witnesses to appear to testify under oath and for companies and individuals to produce evidence, including documents, data, correspondence and physical evidence. [Upper Big Branch Page 112]
	Explicit rights should be provided to any individual who is willing to speak with or provide a statement to MSHA, the state agency or the independent panel during an accident investigation, to do so without the presence, involvement or knowledge of the operator or the operator's agents or attorneys. [Upper Big Branch Page 113]

	Rights should be granted to a deceased miner's immediate next-of-kin to name an individual to serve as a miners' representative in such investigations. [Upper Big Branch Page 113]
	A coordinated, formal debriefing of all mine rescue team members who respond to a major mine emergency should be conducted within a month of the event. The objectives of the assembly would include offering counsel on post-traumatic stress, discussing what worked well and what didn't in their mine emergency response, and identifying team members whose testimony would be helpful to accident investigators. [Upper Big Branch Page 113]
	MSHA and NIOSH should develop an approved rescue vehicle for removing injured miners safely from the mines. State and federal agencies should have a vehicle for removing injured miners and victims from a mine in a safe and efficient manner. Rescue workers should not have to carry miner's great distances underground. [Upper Big Branch Page 110]
2012	Emergency management in underground coal mines needs urgent attention: Operators of underground coal mines should be required by legislation to have a current and comprehensive emergency management plan that is audited and tested regularly; The emergency management plan should be developed in consultation with the workers and the Mines Rescue Service; The emergency management plan should specify the facilities available within the mine, such as emergency equipment, refuges and changeover stations, and emergency exits; The emergency management plan should contain a strategy for notifying next of kin and ensuring that genuine enquirers receive appropriate information; The mining operator must keep and regularly update a comprehensive list of emergency contact details for all workers; The emergency management plan needs to be compatible with CIMS, the co-ordinated incident management system used by New Zealand's emergency services and the police; and The regulator should include the emergency management plan in its audit programme. [Pike River II Page 354]
	The implementation of the co-ordinated incident management system (CIMS) in underground coal mine emergencies should be reviewed urgently: The implementation of CIMS should be reviewed to ensure that emergencies in underground coal mines are well managed; The review team should include the mining industry, police, emergency services, the Mines Rescue Service and the regulator; The CIMS framework should be rigorously tested by regular practical exercises at underground coal mines; and The incident controller at an underground coal mine emergency must have mining expertise and, together with the incident management team, must be responsible for co-ordinating the emergency effort and approving key decisions. This does not prevent a government agency such as the police from being the lead agency or from maintaining its command structure. [Pike River II Page 354-355]
	The activities of the New Zealand Mines Rescue Service need to be supported by legislation: The Mines Rescue Trust Act 1992 should reflect the functions performed by the Mines Rescue Service; and the adequacy and fairness of the current levies imposed on mines to fund the service need to be reviewed. [Pike River II Page 355]
	To support effective emergency management, operators of underground coal mines should be required to have modern equipment and facilities: Operators should be required to have equipment and facilities suitable for self-rescue by workers during an emergency; Operators should be required to include, in their emergency management plans, provisions for continued monitoring of underground atmospheric conditions during an emergency; and Operators should be required to install facilities that will support emergency mine sealing and inertisation. [Pike River II Page 365]
2015	The Ministry of Labour to require mining companies to conduct risk assessments to establish Emergency Response Plans for exploration sites, new mines, surface mines and mining plants. [Mining Review Page 40]
	Workplace Safety North to revise the Mine Rescue Handbook to include guidelines for fitness of crew members, critical incident stress management and acclimatization of emergency responders. [Mining Review Page 40]
	The Ministry of Labour to work with stakeholders to develop proposed recommendations regarding the responsibilities of mine rescue crew members and mine owners/employers, with respect to mine rescue operations. [Mining Review Page 40]

APPENDIX 3E

Table 3.8 Recommendations relating to technology

1967	The National Coal Board should forthwith examine afresh its lines of communication so as to ensure that essential knowledge passes easily and automatically to those whose business it is to become possessed of it and to eliminate those breakdowns and omissions which undoubtedly played a big part in bringing about the Aberfan disaster. [Aberfan Page 128-129]
1976	That task groups set up by the Occupational Health and Safety Authority to advise on codes of practice and statutory regulations relating to technological change in mining include representatives of labour [Royal Commission Page 163]
	That where the location of work is sufficiently remote to warrant the use of technical means of communication and where no illumination other than that of the miner's cap lamp is normally available, an auxiliary source of illumination powered by means other than the miner's lamp battery be provided at the workplace [Royal Commission Page 175]
1981	None
1986	That mine design continue to be recognized as the sole responsibility of management, and that management accept the need to use appropriate technology in designing mines. [Ground Control & Mine Rescue Page 60]
	That guidelines be developed for the interpretation of data produced by ground monitoring devices. [Ground Control & Mine Rescue Page 66]
	That all information obtained from ground monitoring devices at a particular mine be provided to the union representing workers in that mine. [Ground Control & Mine Rescue Page 66]
	That mines experiencing on going rock bursting problems install instruments, such as micro-seismic monitoring devices, to monitor seismicity in the affected areas. [Ground Control & Mine Rescue Page 66]
1995	None
1997	None
2006	Current SCSR technology is almost 20 years old. The federal and state governments, through MSHA and NIOSH, should actively pursue new SCSR technology. All stakeholders must be closely involved in the design, development and testing of these devices. The new generation of SCSRs must be longer-lasting, more reliable units that require single donning with dockable oxygen canisters. This will eliminate the chance of breathing contaminated irrespirable air when changing units. [Sago Page 12]
	Tracking devices that can identify the location of miners at all times underground must be required at all operations. Such technology is currently available and MSHA must require mine operators to provide these devises to all miners working underground. Any system that can increase the ability for miners to escape a mine emergency, even if it is limited in scope, must be utilized. [Sago Page 12]
	MSHA and NIOSH must be mandated to fund and continue to pursue technology to greatly increase the capabilities of wireless tracking devices. The goal of the agencies must be to create a unit that will allow pre- and post-accident tracking of all miners underground. [Sago Page 12-13]
	MSHA must be required to pursue new technologies that will increase the effectiveness of wireless two-way communication in underground mines. As new technology becomes available, mine operators must be required to install it in all their operations. [Sago Page 11]
	Current communication systems must be hardened (reinforced to withstand the forces of an explosion) to increase their survivability. [Sago Page 11]
	A second (redundant) communication system, independent of the mine's current primary system, must be installed in a separate isolated entry. This second communication system must run from the surface to additional phones completely separate from the phones currently underground and must be hardened to increase survivability. [Sago Page 11]
	Current communication technology, including one-way text messaging and two-way wireless systems, must be immediately installed in all mines. Any system that can increase the ability for miners to escape a mine emergency, even if it is limited in scope, must be utilized. [Sago Page 11]
	"Black box" technology must be instituted for mining equipment, including shearers, continuous miners, roof bolters, shuttle cars, motors, conveyors

	and shields. The black boxes should provide information regarding methane, oxygen, carbon monoxide and coal dust levels. [Upper Big Branch Page 109-110]
	Immediate implementation of a computerized, real-time electronic personnel-recording system to formally identify and locate all personnel who are underground at a given time, including supervisory personnel. Redefine the state and federal regulations to ensure that no one, including management, goes underground without a tagging device. [Upper Big Branch Page 110]
	Each mine must be required to institute a "Communication and Information Recording Center" outside the underground portions of underground mines and away from the working areas of surface mines. This communication enters would provide instantaneous communication to MSHA, to state agencies, to company officials and state and country emergency management officials regarding safety and health. [Upper Big Branch Page 110]
	Mine operators should be required to adopt computer-based monitoring of air quality, quantity and direction of flow throughout a mine. A suitable system would alert not only the mine operator and miners to impending danger, but it would also alert the state and federal regulatory agencies. Regulatory agencies would have the authority to shut down an operation based on data provided by the system. [Upper Big Branch Page 110]
	Current monitors for methane, carbon monoxide and coal dust must be upgraded to include memory chips, as well as instant communication to the communications center. [Upper Big Branch Page 110]
	Operators must be required to use real-time continuous monitoring for explosive methane gas and respirable dust in coal mines. [Upper Big Branch Page 110]
	Operators must assess the adequacy of rock dust through direct readout explosibility meters and submit these results electronically to regulatory agencies.
	The state inspector system for writing violations must be converted from paper and pencil to a computerized system. This system must be capable of generating reports for individual mines. [Upper Big Branch Page 110]
	Electronic records should be maintained regarding methane, intake and return air levels on all coal producing sections for no less than seven years. Had this information been available, investigators would have had data related to the previous methane inundation at UBB. [Upper Big Branch Page 110]
	The regulatory agencies should use ventilation simulation models as part of their plan approval and modification process. The simulation model results for each mine would be part of the mine file and available to inspectors for review before commencing an inspection. [Upper Big Branch Page 110]
	Mine operators should be required to install equipment, such as seismographs, to monitor geologic activity at or near their mining operations. [Upper Big Branch Page 110]
	Pre-shift and on-shift examinations must be computerized with the information transmitted to regulatory agencies, much like coal truck weights are transmitted to the Department of Transportation on a daily basis. [Upper Big Branch Page 110]
2012	None
2015	None

APPENDIX 3F

Table 3.9 Recommendations relating to research

1967	None
1976	That the epidemiological research includes a study of 1/ the amount and type of exposure effective in raising cancer mortality, 2/ the pathology of lung cancer in miners, and 3/ the effects of cigarette smoking and of other conjoint occupational factors [Royal Commission Page 96]
	That the mining industry, in co-operation with labour and the Occupational Health and Safety Authority, have conducted research to determine shift-profiles of noise encounter for representative occupations in mines and plants both in the absence and in the presence of actual and best-available hearing protection, that such profiles be codified and published, and that a code be assigned to each worker who regularly encounters areas of work in which noise levels of 85 dB(A) or higher exist [Royal Commission Page 230]
	That pilot plant studies used to develop processes and preliminary operating procedures be extended to include the measurement of factors likely to have an impact on the health and safety of the environment for work [Royal Commission Page 200]
	That the Occupational Health and Safety Branch commission research on the radiographic records related to Miner's Certificates to assess the relative rate of progression of persons in and out of dust [Royal Commission Page 59]
	That the Occupational Health and Safety Authority of the province, in collaboration with the Atomic Energy Control Board, have conducted further epidemiological research based on the exposure to ionizing radiation among Ontario uranium miners [Royal Commission Page 96]
	That the Atomic Energy Control Board: have research conducted relevant to current circumstances a l on means for measuring all components of ionizing radiation effective in contributing significantly to the irradiation of the lungs, other organs, and tissues of workers in Ontario uranium and thorium mines and mills; and h i o n the spatial and temporal distribution of ionizing radiation and related particulates in these mines and mills; issue codes of guidance a l for the frequency and location of sampling required to determine both the radiation exposure of individual workers in Ontario mines and mills and the general state of the mine and mill environment; for the selection, use, maintenance, and calibration of instruments for measuring ionizing radiation both for the determination of individual exposures and for the monitoring of the general mine and mill environment; c l for the identification of persons for whom records of radiation exposure should be kept; and e l l for the form, preservation, and use of occupational records for exposure to all significant components of ionizing radiation;3/facilitate, with the assistance of the federal Department of Health and Welfare, epidemiological research on a national basis [Royal Commission Page 86]
	That the Occupational Health and Safety Branch commission a review of the radiographic record and of the mortality experience for the asbestos nominal roll on a five-year cycle [Royal Commission Page 215]
1981	That the Mines Accident Prevention Association of Ontario, in conjunction with the industry, undertake a comprehensive research program to satisfy the needs which have been identified. [Towards Safe Production Page 234]
	That an independent authority in the field of mine lighting be retained to direct and co-ordinate the research effort [Towards Safe Production Page 234]
	That the Mines Accident Prevention Association of Ontario obtain the concurrence of the managements of three major mining operations and commission a study to determine the extent of the relationship between alcohol and drug use and accidents at each of these operations. [Towards Safe Production Page 235]
	That the results of this study be compared with the results of a survey of the accident report forms submitted to the Workmen's Compensation Board by each of these operations; and that, if the results differ significantly, appropriate changes be made in the manner in which alcohol and drug use is identified and reported as a cause of accidents. [Towards Safe Production Page 235]
	That the study includes an analysis of the organizational arrangements and the systems of control and communication at each of these operations with a view to determining if these factors contribute to the degree of alcohol or drug use by workers within each operation. [Towards Safe Production Page 236]

1986	That mining companies be encouraged to continue conducting independent research programs as they see fit. [Ground Control & Mine Rescue Page 50]
	That mining companies, with the support of labour and government, establish a research organization to act as a central body to co-ordinate research into ground control and rock mechanics in Ontario mines. This co-ordinating body shall be managed by a Board of Directors made up of members currently active in the industry and representing all facets of it - management, labour and government. The Board would appoint an Executive Director who, with an appropriate staff, would manage the research coordination and be accountable to the Board. The initial program would cover at least the following areas: Identify ground control problems in Ontario mines; Identify needed research and the appropriate agencies to conduct it; Contract for the necessary research to be done, and supervise its quality; Ensure that the results of the research are published on a regular basis so that mine management, appropriate labour representatives and government agencies are fully informed; and Participate in the development of guidelines for the implementation of safe ground control practices. [Ground Control & Mine Rescue Page 50-51]
	Among the subjects the organization shall consider for funding are the following: Rock bursts, Destressing, Backfill (including quality monitoring and backfill testing methods), Scaling, Pillar design and recovery, Blasting (including vibration damage and drilling controls), Ground support (including rock bolting and mechanical supports), Monitoring and testing of ground conditions, Mine Lighting, Computer modelling, and Equipment design and mechanization as it applies to hazardous ground conditions. [Ground Control & Mine Rescue Page 51]
	That research into improved rock mechanics instrumentation of all types be undertaken. [Ground Control & Mine Rescue Page 66]
	That specific research to develop improved, reasonable-cost measuring devices be pursued. [Ground Control & Mine Rescue Page 66]
	That research to perfect the development of an effective radio communication device for use underground be continued and accelerated, with active government support. [Ground Control & Mine Rescue Page 58]
1995	It is recommended that funds be made immediately available to undertake an exhaustive international literature and data search, to critically review the literature and data and to prepare a comprehensive state-of-the-art report on the subject of spontaneous combustion in coal mines. [Moura Page 71]
	It is recommended that the research which has been previously undertaken by the committee which was instigated as a result of the Moura 1986 Inquiry be evaluated as soon as possible by representatives from the Inspectorate, Miner's Union, and Coal Operators, in order to determine the most appropriate method of inertisation for Queensland coal mines. [Moura Page 70]
1997	As a prerequisite to the resumption of underground coal mining at Westray or elsewhere in the Pictou coal basin, the province should require the completion of a study into the safety and economic factors involved in drainage of the coalbed methane in the mining area concerned. [Westray Page 314]
	The Department of Labour and the Department of Natural Resources should consider active research in the development and use of passive and triggered stonedust and water barriers for the drives and entries of underground coal mines. This research should be aimed at the development of such techniques for use in room-and-pillar mining operations. If the development of barrier technology indicates that substantial safety benefits may accrue, the regulator could order a mine operator to install water or stonedust barriers in the mine. [Westray Page 349]
	The Government of Canada, through the Department of Justice, should institute a study of the accountability of corporate executives and directors for the wrongful or negligent acts of the corporation and should introduce in the Parliament of Canada such amendments to legislation as are necessary to ensure that corporate executives and directors are held properly accountable for workplace safety. [Westray Page 601]
2006	MSHA and NIOSH must be mandated to fund and direct continued studies and research to develop a new generation of wireless communications technology. [Sago Page 11]
2011	None
2012	None
2015	The Mining Legislative Review Committee to align the majority of its work with the major hazards identified in the sector level risk assessment

	exercise. [Mining Review Page 29]
	The Ministry of Labour to work with its Research Advisory Council to focus its grants and research on topics that address the priority hazards identified in the Mining Sector Risk Assessment, and disseminate and act upon the findings where appropriate. In particular, the Review identified several research opportunities: Defining the scientific basis for de-stressing practices, and developing guidance materials that define best practices for de-stressing; Exploring options for collaborating with technology developers to mitigate risks associated with seismicity and rock bursting (i.e. similar to the Australian Centre for Geomechanics model); and Defining and quantifying the harmful health and safety effects of worker fatigue in the Ontario Mining Sector, and researching other sectors (e.g. transportation, health care and the military) to see how the mining sector compares, and how the problem has been managed. [Mining Review Page 29]

APPENDIX 4

Table 4.3: Number of references for each seeded safety culture term over a 50-year timeline

	1967	1976	1981	1986	1995	1997	2006	2011	2012	2015	
Attention	0	2	23	0	0	26	0	1	13	3	68
Attitude	0	2	123	1	2	27	0	2	5	0	162
Attributes	0	0	0	1	0	0	0	0	0	0	1
Behaviour	2	4	88	0	0	12	0	0	11	1	118
Belief	3	7	31	1	1	19	3	4	7	3	79
Characteristics	0	0	38	0	0	0	0	1	6	1	46
Commitment	0	4	55	0	0	20	0	5	11	0	95
Competencies	8	5	18	6	0	61	0	1	17	3	119
Ethical	0	1	0	0	0	5	0	0	0	0	6
Experiences	0	0	6	0	0	0	0	0	1	0	7
Feelings	0	0	16	0	0	1	0	1	1	1	20
Interpretations	0	0	4	0	0	0	0	0	0	0	4
Mental	0	1	6	0	0	0	0	0	0	0	7
Morals											0
Norms	0	0	0	0	1	0	0	3	1	0	5
Observable	0	1	0	0	0	0	0	0	0	0	1
Patterns	1	0	8	0	0	0	0	0	2	1	12
Perceptions	0	1	11	0	3	4	0	0	0	0	19
Psychological	0	0	4	0	0	0	0	0	0	0	4
Rituals											0
Safety culture	0	0	0	0	1	0	0	8	37	7	53
Shared	1	0	8	0	0	3	0	1	6	1	20
Situational	0	0	3	0	0	0	0	0	0	1	4
Social practices	1	7	22	1	1	33	0	8	8	2	83
Thoughts	0	0	12	0	0	1	0	0	0	0	13
Value	0	0	2	1	0	2	0	1	2	0	8
TOTALS	16	35	478	11	9	214	3	36	128	24	

APPENDIX 5

APPENDIX 5A Recommendations pertaining to the Mining Legislative Review Committee's new subcommittees.

Ground Control	
1967	Present managers and surveyors should as soon as possible receive training in ground-water conditions and the rudiments of soil mechanics so as to be able to appreciate the significance of the reports of, and opinions expressed by, the experts in these subjects. The statutory qualifications for managers and surveyors should in future include awareness of the elements of soil mechanics and hydrogeology, in addition to the geology which is already comprised in the syllabus. The Unit Mechanical Engineer and charge hand should be instructed in the significance of tip deformation and of the appearance or disappearance of water-courses. In addition, the charge hand should be trained to record at frequent intervals on a pro-forma a simple questionnaire dealing with such matters as toe-movement, crest-sinking, cracks and breaks. These records should be kept at the Unit Office and inspected regularly by the manager and mechanical engineer. They should also be produced to the civil engineer charged with tip responsibility and to Her Majesty's Inspectors of Mines on the occasion of each visit to the tip. [Aberfan Page 128]
1981	That work crews are formally and systematically made aware of ground conditions in the areas in which they are working. [Towards Safe Production Page 234]
1986	That soft rock mining operations be considered separately from hard rock mining in setting standards related to ground control practices. [Ground Control & Mine Rescue Page 68]
	That within one year of the release of this report lighting standards - as they relate to ground control and emergency preparedness - shall be established for use in all underground mines. [Ground Control & Mine Rescue Page 64]
	That auxiliary high-intensity lighting be available in all active work areas to assist in ground-control- related activities such as inspection and scaling. [Ground Control & Mine Rescue Page 64]
	That the Ministry of Labour review and monitor the regional stability affecting underground mines in Ontario, and discuss potential problems with the mining companies involved. [Ground Control & Mine Rescue Page 61]
	That mining companies sharing a common boundary exchange information that may affect the regional stability of either or both. [Ground Control & Mine Rescue Page 61]
	That workplace mining plans be made available to miners and be discussed with them, including any indications of abnormal ground conditions, geological anomalies, and the location of ground monitoring instruments, as a method of ensuring worker participation in planning ground control procedures in the "micro" environment. [Ground Control & Mine Rescue Page 61]
	That every underground mine be required to prepare a ground control macro-environment design prior to the introduction of a new mining method, or the introduction of any expansion of the present mine design; such designs shall be submitted to the Ministry of Labour as required by Section 5 of the Mining Regulations. [Ground Control & Mine Rescue Page 60]
	That technically competent personnel of the Ministry of Labour review ground control design and procedures at all Ontario mines, at the mine site, at least once per year, and more frequently as required. [Ground Control & Mine Rescue Page 60]
	That companies reassess the effectiveness of their methods of providing information on ground control and emergency preparedness to employees. [Ground Control & Mine Rescue Page 58]
	That these inspectors enforce ground control regulations more vigorously. [Ground Control & Mine Rescue Page 69]
	That the Ministry of Labour establish a Technical Support Centre with the following functions: to support an expanded role in pre-development review and annual mine design review as recommended elsewhere in this report; to establish facilities for training in ground control (although this should not conflict with existing established training programs); to develop, and provide to mines on short term loan, ground control instruments and

	testing equipment; to establish and maintain a computerized data base containing operational information on ground control and emergency preparedness and provide access to it to the mining industry, and to the research coordinating body recommended elsewhere in this report; to develop and maintain a library of computer software related to ground control technology, and especially to the interpretation of data from ground control monitoring devices; the specialist ground control engineers employed in the Technical Support Centre should not be involved in the regulatory functions of the Ministry; and the Technical Support Centre shall not be in conflict with the research coordinating body recommended elsewhere in this report. [Ground Control & Mine Rescue Page 68-69]
	That any evaluations of ground conditions in areas being mined shall be given to the union representing workers in each mine, and shall also be communicated directly to the workers involved. [Ground Control & Mine Rescue Page 66]
	That all miners receive periodic refresher courses in ground control if required. Labour shall be encouraged to participate in the development of the curriculum. [Ground Control & Mine Rescue Page 52]
	That miners who have been off the job for one year or more should be evaluated with respect to their knowledge of current ground control practices, and should received appropriate training where necessary before they return to regular underground work. [Ground Control & Mine Rescue Page 52]
	That a separate section on ground control be added to the skills included in the Common Core training for new underground miners. [Ground Control & Mine Rescue Page 52]
	That non miners working underground be trained in the fundamentals of ground control, including the recognition of potential hazards. [Ground Control & Mine Rescue Page 53]
	That additional funding be made available to colleges and universities to provide the improved facilities and instruction necessary to permit adequate training in ground control. [Ground Control & Mine Rescue Page 545]
	That the mining industry shall establish a special chair in ground control at an Ontario university to improve the standard of teaching in rock mechanics for graduate and undergraduate students, and to conduct research projects directly related to the mining industry. This chair shall be closely identified with the Ontario mining industry, and shall take direction from the industry. [Ground Control & Mine Rescue Page 55]
	That community colleges and universities offering mining programs be encouraged to develop additional short courses in ground control, targeted to specific groups in the mining industry. [Ground Control & Mine Rescue Page 56]
	That the Ministry of Labour, through training and recruitment, ensure that its ground control staff be at a world-class level in their discipline, and have the credibility to relate effectively to the international ground control community. [Ground Control & Mine Rescue Page 68]
	That Ministry of Labour inspectors be provided with such additional training as may be required to enable them to deal effectively with site-specific ground control problems. [Ground Control & Mine Rescue Page 69]
	That health and safety committee members shall receive the same training in ground control as supervisory staff. [Ground Control & Mine Rescue Page 53]
	That worker-inspectors, where they exist, be given the same training in ground control as that recommended for supervisory staff elsewhere in this report. [Ground Control & Mine Rescue Page 69]
	That instruction in ground control be integrated into the undergraduate programs in mining engineering. The Rock Mechanics and Strata Control Committee of the Canadian Institute of Mining and Metallurgy shall be asked to effect this change through the organization of a National Forum on mining-related ground control education. [Ground Control & Mine Rescue Page 56]
	That the present tripartite committee established to approve modular training programs shall expand those programs to include specialist modules on ground control for all underground miners. [Ground Control & Mine Rescue Page 52]
	That all mining supervisory staff receive adequate training in ground control. The ground control module for supervisors being developed by the tripartite committee on modular training shall be deemed adequate for this purpose. [Ground Control & Mine Rescue Page 53]
	That certification courses be developed in practical ground control for practicing ground control engineers and other technical personnel. [Ground

	Control & Mine Rescue Page 56]
	That guidelines be developed for the interpretation of data produced by ground monitoring devices. [Ground Control & Mine Rescue Page 66]
	That all information obtained from ground monitoring devices at a particular mine be provided to the union representing workers in that mine. [Ground Control & Mine Rescue Page 66]
	That mines experiencing on going rockbursting problems install instruments, such as micro-seismic monitoring devices, to monitor seismicity in the affected areas. [Ground Control & Mine Rescue Page 66]
	That mining companies, with the support of labour and government, establish a research organization to act as a central body to co-ordinate research into ground control and rock mechanics in Ontario mines. This co-ordinating body shall be managed by a Board of Directors made up of members currently active in the industry and representing all facets of it - management, labour and government. The Board would appoint an Executive Director who, with an appropriate staff, would manage the research coordination and be accountable to the Board. The initial program would cover at least the following areas: Identify ground control problems in Ontario mines; Identify needed research and the appropriate agencies to conduct it; Contract for the necessary research to be done, and supervise its quality; Ensure that the results of the research are published on a regular basis so that mine management, appropriate labour representatives and government agencies are fully informed; and Participate in the development of guidelines for the implementation of safe ground control practices. [Ground Control & Mine Rescue Page 50-51]
	That specific research to develop improved, reasonable-cost measuring devices be pursued. [Ground Control & Mine Rescue Page 66]
	That research into improved rock mechanics instrumentation of all types be undertaken. [Ground Control & Mine Rescue Page 66]
	Among the subjects the organization shall consider for funding are the following: Rock bursts, Destressing, Backfill (including quality monitoring and backfill testing methods), Scaling, Pillar design and recovery, Blasting (including vibration damage and drilling controls), Ground support (including rock bolting and mechanical supports), Monitoring and testing of ground conditions, Mine Lighting, Computer modelling, and Equipment design and mechanization as it applies to hazardous ground conditions. [Ground Control & Mine Rescue Page 51]
1997	The legislation and regulations governing coal mines should be reviewed to ensure that all personnel working underground receive training in ground control as appropriate to their activities and responsibilities. In particular: Coal miners should receive a course on ground control as part of their basic mine training, plus annual refresher courses on ground control; Mining supervisory staff, including mine managers, underground managers, and overmen, should receive extensive training in ground control; Non-mining personnel employed underground should receive sufficient training in ground control to enable them to recognize potential hazards; Training programs for these three categories of employee should be developed by mine management in cooperation with the joint occupational health and safety committee and the regulator. The regulator should review these training programs to ensure that they reflect changing technology and mining practices. [Westray Page 385]
	If it is decided to pattern the Nova Scotia coal mine regulation regime after that of the United Kingdom, all mine inspectors should have at least a degree in mining engineering, with some specialist training in both rock mechanics and ventilation relating to underground coal mining. If the U.S. Mine Safety and Health Administration approach is adopted, all mine inspectors should receive adequate initial training. In either case, all mine inspectors should be required to take periodic training, of at least one week per year, at an institute specializing in mine inspection and safety. [Westray Page 543]
	The regulations should specify the following at a minimum: Ground control plans and any revisions to those plans should be prepared by the mine operator and submitted to the regulator for approval prior to the implementation of any such plans; The ground control plan should show the existing geological conditions and the mining system to be used. The plan should also indicate any unusual hazards and outline the manner in which these will be handled; Approved plans should be available to miners and other underground workers and should be posted in the mine at the area affected by the plan; and What the plan is required to specify should be set forth by the regulator from time to time, and should include: a columnar section of mine strata; planned width of openings and size of pillar (if required); thickness of seam; method of support to be used; type, sequence, and spacing of support materials; requirements for temporary roof support systems; and type and thickness of strata in the roof and in the floor for a depth of 3 m below the coal bed. The regulator may require further and better information on the plan and may require that the plan be reviewed by a qualified

	specialist in rock mechanics. The regulator may require revisions to the plan at any time if satisfied that conditions or accident experience indicate that such revisions are necessary or conducive to safety. The ground control plan should be reviewed at least once every six months by the regulator. The mine operator should record on the plan and report to the regulator any unplanned fall of roof or rib or any significant rock burst (more than 0.3 m in thickness) that occurs above the bolt anchorage area, impairs ventilation, impedes the passage of persons, causes injury to miners, causes miners' withdrawal from the area, or disrupts activities for more than one hour. All roof control materials should conform with standards as established by various testing agencies such as the Canadian Standards Association (CSA) or the American Society for Testing and Materials Specifications (ASTMS). In the absence of standards, such materials could be approved by the regulator. The regulator should from time to time issue directions, such as found in 30 CFR, respecting the use of roof bolts, torquing requirements for roof bolts, and testing requirements for roof bolts and for other types of roof support systems. All entries and drives where roof bolting is the main means of roof support should have imbedded warning devices that monitor any downward movement in the roof strata. Such warning devices should be of a type approved by the regulator and should be placed at intervals specified on the plan. Installation of such devices should not relieve the operator from making regular inspections as prescribed. (The type of device referred to here is that generic category in which the "tell-tale" extensometer — the simple mechanical gauge produced at the CANMET Coal Research Laboratory in Cape Breton — would be included.) [Westray Page 384]
2015	The Ministry of Labour to work with its Research Advisory Council to focus its grants and research on topics that address the priority hazards identified in the Mining Sector Risk Assessment, and disseminate and act upon the findings where appropriate. In particular, the Review identified several research opportunities: Defining the scientific basis for de-stressing practices, and developing guidance materials that define best practices for de-stressing; Exploring options for collaborating with technology developers to mitigate risks associated with seismicity and rock bursting (i.e. similar to the Australian Centre for Geomechanics model); and Defining and quantifying the harmful health and safety effects of worker fatigue in the Ontario Mining Sector, and researching other sectors (e.g. transportation, health care and the military) to see how the mining sector compares, and how the problem has been managed. [Mining Review Page 29]
	The Ministry of Labour to require that mining employers to address the priority hazards identified in the risk ranking exercise: Enhance ground control protection by identifying key elements in the control of these hazards, and requiring employers to maintain a record of significant seismic events in addition to incidents of ground instability; Require employers to prepare a formal plan to manage hazards that cause occupational illness, including requirements for worker and supervisor training and communication; and Require all underground mines employers to have in place a formal water management program; Specify that precautions be taken by employers to guard against the accumulation of water in bins, ore and waste passes and chutes; and Require all underground mines to have in place a formal traffic management plan. [Mining Review Page 29-30]
Traffic Management	
2006	Tracking devices that can identify the location of miners at all times underground must be required at all operations. Such technology is currently available and MSHA must require mine operators to provide these devises to all miners working underground. Any system that can increase the ability for miners to escape a mine emergency, even if it is limited in scope, must be utilized. [Sago Page 12]
	MSHA and NIOSH must be mandated to fund and continue to pursue technology to greatly increase the capabilities of wireless tracking devices. The goal of the agencies must be to create a unit that will allow pre- and post-accident tracking of all miners underground. [Sago Page 12-13]
	All mobile equipment entering the mine during rescue and recovery efforts must be equipped with two- way communications. [Sago Page 15]
2011	Immediate implementation of a computerized, real-time electronic personnel-recording system to formally identify and locate all personnel who are underground at a given time, including supervisory personnel. Redefine the state and federal regulations to ensure that no one, including management, goes underground without a tagging device. [Upper Big Branch Page 110]
	“Black box” technology must be instituted for mining equipment, including shearers, continuous miners, roof bolters, shuttle cars, motors, conveyors and shields. The black boxes should provide information regarding methane, oxygen, carbon monoxide and coal dust levels. [Upper Big Branch Page 109-110]

Water Management	
1997	As a prerequisite to the resumption of underground coal mining at Westray or elsewhere in the Pictou coal basin, the province should require the completion of a study into the safety and economic factors involved in drainage of the coalbed methane in the mining area concerned. [Westray Page 314]
	The Department of Labour and the Department of Natural Resources should consider active research in the development and use of passive and triggered stonedust and water barriers for the drives and entries of underground coal mines. This research should be aimed at the development of such techniques for use in room-and-pillar mining operations. If the development of barrier technology indicates that substantial safety benefits may accrue, the regulator could order a mine operator to install water or stonedust barriers in the mine. [Westray Page 349]
	Sufficient water should be provided in the mine to ensure that an adequate supply is available to wet the coal being mined and transported within the mine: All coal-cutting picks should be equipped with water-spray jets of sufficient number and size to ensure that the areas of the coal face being worked are maintained in a damp condition so as to render any coal dust incombustible; and All transfer points where coal is moved from one mode of transport to another should be equipped with water-spray devices sufficient to render any coal dust incombustible. [Westray Page 349]
Ventilation & Industrial Hygiene	
1976	That the epidemiological research includes a study of 1/ the amount and type of exposure effective in raising cancer mortality, 2/ the pathology of lung cancer in miners, and 3/ the effects of cigarette smoking and of other conjoint occupational factors [Royal Commission Page 96]
	That the mining industry, in co-operation with labour and the Occupational Health and Safety Authority, have conducted research to determine shift-profiles of noise encounter for representative occupations in mines and plants both in the absence and in the presence of actual and best-available hearing protection, that such profiles be codified and published, and that a code be assigned to each worker who regularly encounters areas of work in which noise levels of 85 dB(A) or higher exist [Royal Commission Page 230]
	That pilot plant studies used to develop processes and preliminary operating procedures be extended to include the measurement of factors likely to have an impact on the health and safety of the environment for work [Royal Commission Page 200]
	That the Occupational Health and Safety Branch commission a study of the mortality experience of the Ontario Uranium Nominal Roll relative to appropriately matched sample populations of non-uranium miners and non-miners in Ontario [Royal Commission Page 91]
	That the Occupational Health and Safety Authority of the province, in collaboration with the Atomic Energy Control Board, have conducted further epidemiological research based on the exposure to ionizing radiation among Ontario uranium miners [Royal Commission Page 96]
	That the Atomic Energy Control Board: have research conducted relevant to current circumstances and on means for measuring all components of ionizing radiation effective in contributing significantly to the irradiation of the lungs, other organs, and tissues of workers in Ontario uranium and thorium mines and mills; and hi on the spatial and temporal distribution of ionizing radiation and related particulates in these mines and mills; issue codes of guidance al for the frequency and location of sampling required to determine both the radiation exposure of individual workers in Ontario mines and mills and the general state of the mine and mill environment; for the selection, use, maintenance, and calibration of instruments for measuring ionizing radiation both for the determination of individual exposures and for the monitoring of the general mine and mill environment; cl for the identification of persons for whom records of radiation exposure should be kept; and ell for the form, preservation, and use of occupational records for exposure to all significant components of ionizing radiation;3/facilitate, with the assistance of the federal Department of Health and Welfare, epidemiological research on a national basis [Royal Commission Page 86]
	That the Occupational Health and Safety Branch commission research on the radiographic records related to Miner's Certificates to assess the relative rate of progression of persons in and out of dust [Royal Commission Page 59]
	That profiles of risk-encounter for toxic substances be developed by examining the work patterns of maintenance workers, and that modular training be adapted to such profiles [Royal Commission Page 206]
	That resources for joint research and teaching by specialists in occupational health and safety in faculties of medicine and engineering be given high

	priority by both the universities and government [Royal Commission Page 205]
	That the radiological status of silicosis in the dust-exposed population currently employed in the Elliot Lake uranium mines and all other uranium mines be reviewed by the Occupational Health and Safety Branch on a biennial basis for a period of at least ten years [Royal Commission Page 33]
	That the radiological status of silicosis among the persons on record on the Uranium Nominal Roll be reviewed on a biennial basis for a period of at least ten years [Royal Commission Page 33]
	That the functional purpose, measuring procedures, and measured results relating to all environmental monitoring at the workplace be made known in understandable language to all affected workers and their representatives by the employer and as appropriate by the Mine Inspection Branch [Royal Commission Page 40]
	That the Mines Inspection Branch within the Occupational Health and Safety Authority conduct annually, or have conducted by an independent agency, sample measurements at representative workplaces of all environmental quantities whose values are audited by the branch in carrying out its role [Royal Commission Page 43]
	That the Occupational Health and Safety Authority publish at least biennially a critical review of its appraisal of environmental conditions at the workplaces in the mines and mineral plants [Royal Commission Page 44]
	That the Occupational Health and Safety Authority establish by regulation a dust standard for personal exposure to free silica in mine and plant aerosols based on a time-weighted average of respirable dust intensity over a working shift and a stipulated lifetime period of exposure [Royal Commission Page 50]
	That the dust standard for time-weighted average exposure be established on a statutory basis [Royal Commission Page 50]
	That the Occupational Health and Safety Authority immediately establish by regulation an initial threshold limit value (11 v) for the mass of respirable free silica in milligrams per cubic metre [Royal Commission Page 50]
	That the interim have the status accorded by the Occupational Health and Safety Authority to threshold limit values as issued by the American Conference of Governmental Industrial Hygienists [Royal Commission Page 51]
	That the Occupational Health and Safety Branch prepare a code of requirements for the gravimetric measurement of dust in all mines suited to determining personal exposure to dust [Royal Commission Page 51]
	That all steps necessary to render effective a gravimetric standard of dust measurement, including those listed herein, be implemented immediately [Royal Commission Page 51]
	That to provide a basis for establishing a statutory standard or standards for time-weighted average respirable dust exposure in Ontario mines and plants, the Occupational Health and Safety Branch commission epidemiological research on the relation of the incidence of silicosis and ofother pulmonary effects to the structure and quantity of aerosols respired in Ontario mines [Royal Commission Page 53]
	That the existing code of requirements for dust measurement in the uranium mines as issued by the chief engineer of the Mines Engineering Branch remain in force [Royal Commission Page 53]
	That the Occupational Health and Safety Authority be assigned by statute the responsibility to establish standards or guidelines for personal exposure to all toxic substances and hazardous physical agents and that, subject to any statutory standards and in consultation with industry and labour, the Authority issue a code of practice for the application in mines and plants of the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists [Royal Commission Page 235]
	That the Atomic Energy Control Board confirm the extent to which thoron gas and its daughter products contribute to the irradiation of the respiratory system and other organs of workers in Ontario uranium mines [Royal Commission Page 68]
	That any employer who rotates job assignments for workmen with the intent of limiting the occupational exposure of any persons to any hazardous environmental condition be required to obtain the formal approval of the Occupational Health and Safety Branch and to maintain permanent occupational records which clearly define the persons, tasks, locations, hazardous conditions, and time intervals involved [Royal Commission Page

	57]
	That workers in reduction plants who have been exposed for twenty years or longer to Sulphur dioxide at levels approaching the current Threshold Limit Value and to associated dust and fumes, and who exhibit the clinical diagnosis of chronic bronchitis and impaired pulmonary function as identified by objective tests, be considered for compensation at up to a maximum of 20 per cent disability [Royal Commission Page 219]
	That when the lungs of a worker exhibit dust effects and the worker seeks the opportunity through work adjustment to take employment with a new employer, the new employer not be held liable for any disability pension or other costs for silicosis or disease conditions related thereto that may be levied as a consequence of the person becoming a silicotic at a future date [Royal Commission Page 59]
	That the current employees in the Elliot Lake uranium mines who are silicotics or exhibit dust effects (radiographic 4) in their lungs be eligible fora voluntary programme of work adjustment; that this programme be supported by management and unions; and that the Workmen's Compensation Board provide rehabilitative compensation and supportive counselling services to assist the persons involved [Royal Commission Page 57]
	That persons on the Uranium Nominal Roll who exhibit dust effects (radiographic 4) within twenty years of entry into Ontario dust exposure, and who have been employed in dust exposure in the uranium mines fora cumulative interval of five or more years from 1954 to 1975 inclusive, be eligible for rehabilitation assistance under a programme of work adjustment [Royal Commission Page 60]
	That where there is evidence that the exposure of any person to silicaladen dust has been substantially in excess of established dust guidelines or standards and the person has exhibited dust effects in his or her lungs within twenty years of first exposure to dust in Ontario, the person be eligible for work adjustment rehabilitation assistance [Royal Commission Page 60]
	That the Workmen's Compensation Board of Ontario, in collaboration with other provincial boards as provided for in interprovincial agreements, seek out and advise the families of all ascertained deaths due to lung cancer on the Nominal Roll that a claim for compensation should be entered [Royal Commission Page 109]
	That where more than one recognized toxic component is present in the aerosols the standard specify how an effective combined exposure limit is to be determined [Royal Commission Page 53]
	That tests using sputum cytology be conducted every two years on all persons who have worked in radiation exposure at the uranium mines for five or more years [Royal Commission Page 108]
	That the Atomic Energy Control Board review the basis for and issue explicit regulations establishing the maximum permissible annual exposure to ionizing radiation for workers in uranium and thorium mines and mills [Royal Commission Page 86]
	That the regulations for maximum permissible exposure delineate how all significant components of external and internal irradiation are to be accounted for and indicate how total exposure and related dose is to be evaluated [Royal Commission Page 86]
	That the regulations for maximum permissible exposure and related dose be interpreted in units that can be monitored by practical means in uranium and thorium mines and mills [Royal Commission Page 86]
	That the Province of Ontario, through the Occupational Health and Safety Authority, establish by statute a standard for maximum permissible annual exposure to ionizing radiation for workers in uranium and thorium mines and mills, and that this standard be in conformity with the regulatory standards of the Atomic Energy Control Board [Royal Commission Page 87]
	That the Mines Inspection Branch prepare regulations defining the kinds and frequencies of measurements of ventilation, dust and radiation necessary to enable it to audit the engineering operational characteristics of uranium and thorium mines and mills [Royal Commission Page 88]
	That these regulations be in conformity with the related code of guidance established by the Atomic Energy Control Board [Royal Commission Page 88]
	That the Occupational Health and Safety Authority specify: a level of radiation in mine or mill air measured at any time in any occupied workplace which, if exceeded, requires that corrective action be taken immediately; and a level of radiation in mine or mill air measured at any time in any occupied workplace which, if exceeded, requires closure of the related workplace until the level of radiation is reduced below that specified in 1

	[Royal Commission Page 88]
	That job rotation within mines conducted to meet the standard for maximum permissible annual exposure to ionizing radiation be permitted only in exceptional circumstances with the explicit approval on a case-by-case basis of the Occupational Health and Safety Branch and with the knowledge of the representatives of the workers [Royal Commission Page 105]
	That, by statute, each mining company be made responsible for maintaining effective audiometric records for each employee who in the absence of hearing protection regularly encounters noise at levels of 85 dB(A) or higher, and that such audiometric records be required to be keyed 1/ to social insurance numbers, 2/ to Miner's Certificate numbers where such have been assigned, and 3/ to a code number of noise-profile-encounter as previously recommended [Royal Commission Page 232]
	That the Occupational Health and Safety Branch commission on a five-year cycle statistical assessments of the state of hearing among sample populations of workers in mines, and that the first review be of production crews in underground operations, including diesel operators [Royal Commission Page 232]
	That a record of the substances and human effects of acute encounters with toxic substances leading to medical aid and compensable injuries be maintained in the occupational health records of each worker at the company level [Royal Commission Page 207]
	That a nominal roll of workers at risk of exposure to nickel carbonyl in reduction plants and pilot plants be established by the Occupational Health and Safety Authority, in co-operation with the industry and that the morbidity and the mortality experience of this nominal roll be reviewed at least every five years [Royal Commission Page 213]
	That the Occupational Health and Safety Authority establish, with the co-operation of the Workmen's Compensation Board and the mining industry, a nominal roll of all persons who have worked one or more months in exposure to asbestos dust in asbestos mines and plants [Royal Commission Page 215]
	That at five-year intervals the Occupational Health and Safety Branch commission a review of the status of the health of samples of persons who are at high risk from acute encounters with toxic substances, including as necessary intensive medical surveillance [Royal Commission Page 207]
	That the Occupational Health and Safety Branch commission a review of the radiographic record and of the mortality experience for the asbestos nominal roll on a five-year cycle [Royal Commission Page 215]
	That epidemiological reviews of selected populations subject to chronic exposure to toxic substances in reduction plants and mines matched to suitable control groups be conducted on a five-year cycle by or under the guidance of the Occupational Health and Safety Branch and that the essential results of such studies be summarized and published upon completion [Royal Commission Page 212]
	That the Occupational Health and Safety Branch be assigned by provincial statute the responsibility to direct: the establishment and review of occupational health records for workers in uranium and thorium mines and mills, for regulatory and epidemiological purposes; the preparation of a code of practice for the sampling and measurement of ionizing radiation in a manner suited to the determination of the exposures of individual workers in uranium and thorium mines and mills and that this code of practice be in conformity with the code of guidance issued by the Atomic Energy Control Board [Royal Commission Page 87]
	That the Occupational Health and Safety Branch of the province conduct or have conducted and publish on a regular cycle not exceeding five years status reports on the evolution of occupational diseases among miners [Royal Commission Page 32]
	That the system of measurement and reporting being conducted by the Mines Accident Prevention Association continue in operation and be subject to independent monitoring as recommended [Royal Commission Page 54]
	That each uranium mine install a central monitoring system for its ventilation network to monitor air flow and air quality as indicated by dust, radiation, and other contaminants [Royal Commission Page 102]
	That the Mines Inspection Branch audit the engineering records of performance of mine ventilation systems [Royal Commission Page 102]
	That records of personal exposure to ionizing radiation maintained by the mines be keyed to Miner's Certificate numbers in sequence and to social

	insurance numbers in sequence and arranged in a format that facilitates linking to the Mining Master File [Royal Commission Page 107]
	That the frequency of regular radiographic examination of dust- exposed mine workers be reduced to once every two years unless a radiographic change was apparent at the last examination [Royal Commission Page 107]
	That there be a statutory requirement for a metallurgical audit of origin, holdup, and destination of potentially dangerous minor elements such as lead, mercury, arsenic, selenium, tellurium, cadmium, and antimony to be conducted quarterly in all reduction plants on the basis of extended standard monthly sampling and analytical procedures, and that a copy of this audit be sent to the Occupational Health and Safety Authority [Royal Commission Page 200]
	That there be a statutory requirement for an annual audit of use by mass of toxic and hazardous reagents and that a copy be sent to the Occupational Health and Safety Authority [Royal Commission Page 200]
	That there be a statutory requirement for each mining company to maintain a register of servicing chemicals involved in any personal encounter associated with a medical aid or compensable injury; that the register specify both trade name and chemical composition and identify all known toxic chemical constituents; that the register include an audit by mass of annual use; and that a copy of this register be provided to the Occupational Health and Safety Authority [Royal Commission Page 204]
	That there be a statutory requirement for each mining company to give the Occupational Health and Safety Authority notice of intent to introduce any new reagent or servicing chemical whose toxic characteristics are not known [Royal Commission Page 204]
	That with respect to codes of practice and schemes of practice the principles of recommendations 8, 9, and 10 be extended 1/ to the maintenance and operation of mills and metallurgical plants as these activities relate to the leaking and spilling of toxic substances and hot materials into workplaces; 2/ to the handling and use of reagents and servicing chemicals and to the consequences of their leaks and spills [Royal Commission Page 204]
	That at any location of regular work where acute encounters with toxic substances repeatedly occur as a result of leaking, recirculating, or spilling from metallurgical and milling processes, there be a statutory requirement for the installation and use of equipment for the continuous monitoring of the substances involved [Royal Commission Page 206]
	That the appropriate substance or intent of recommendations 8, 9, 10, 39(2), 40, 42, and 46 be made applicable to asbestos mines and plants [Royal Commission Page 215]
	That the Occupational Health and Safety Authority, in co-operation with the industry and labour, prepare a code of requirements for diesel emissions [Royal Commission Page 222]
	That the Mines Inspection Branch prepare a code of practice for the provision of ventilation and for the fuelling, operation, and maintenance of diesel engines [Royal Commission Page 222]
	That each mine using diesel equipment be required to file with the Mines Inspection Branch a scheme of practice for the short-term and long-term maintenance of its diesel engines [Royal Commission Page 222]
	That each mining operation maintain noise maps based on full-scale conditions of operation which delineate all areas of work at which the noise level is 85 dB(A) or higher [Royal Commission Page 229]
	That the Occupational Health and Safety Branch regularly inspect all audiometric testing facilities not under the supervision of a designated medical specialist, and that any designated medical specialist be required to certify biennially in writing that the facilities under his supervision conform to the minimum standards of the Branch as then current [Royal Commission Page 233]
	That the mining industry and equipment manufacturers, with the Canadian Standards Association, expedite the development of standards for the assessment of noise from mining equipment, and for the performance of personal safety equipment and cab enclosures in attenuating noise, and that such standards be invoked by the industry in specifying noise performance requirements for new equipment [Royal Commission Page 230]
	That the Occupational Health and Safety Authority issue a code of practice for the selection and use of personal hearing protection and for communicating in the presence of noise [Royal Commission Page 231]

	That the mining industry establish for its employees, where such is not now provided, occupational health surveillance by a supervising medical director or consultant experienced in occupational medicine [Royal Commission Page 237]
	That the labour unions individually or in consort appoint to their staff a consulting specialist in occupational medicine [Royal Commission Page 237]
	That the Mines Inspection Branch within the Occupational Health and Safety Authority, in consultation with industry and the representatives of workers, prepare, under clearly defined statutory authority, codes of practice applicable to all mines relating to: 1/ the prevention and confinement of dust at each distinctive class of workplace; 2/ the provision of ventilation in the breathing zone of workers that is effective for purposes of protecting health at each distinctive class of workplace (including vehicles) [Royal Commission Page 49]
1986	Operators must assess the adequacy of rock dust through direct readout explosibility meters and submit these results electronically to regulatory agencies.
1995	It is recommended that all employees be effectively trained to: recognize indicators of specific mine hazards, such as spontaneous combustion, and their control; and become sufficiently familiar with mine gases, and associated risks. [Moura Page 64]
	It is recommended that a position of ventilation officer be established as a statutory position at all underground coal mines. The ventilation officer appointed must have demonstrated competencies appropriate to the duties and responsibilities of the position and would be directly responsible to the mine manager for the planning, design and implementation of the mine ventilation system and for the establishment of effective standards of ventilation for the mine, methods for its control and protection, monitoring of performance, reporting procedures, maintenance of ventilation records and plans, and emergency action plans. [Moura Page 65]
	It is further recommended that both new and existing mines make provision for the rapid sealing of the mine from the surface through the installation of an air lock facility in at least one of the mine intakes for ready access to re-enter the mine. The plan should also indicate the location of any surface boreholes that may facilitate the monitoring of the underground atmosphere. [Moura Page 72]
	It is further recommended that Mine Safety Management Plans be based on detailed risk/hazard analyses. [Moura Page 62]
	The Inquiry recommends that minimum requirements provide for: the continuous and effective sampling and monitoring of the atmosphere in a sealed area including a minimum number of sampling points and suitable location(s); means whereby the pressure difference between the inside and outside surfaces of seals can be measured; the effective ventilation of the outside surfaces of seals; and regular inspection and periodic auditing on the long term performance of seals and sealed areas. [Moura Page 69]
	It is recommended that mines be required to develop and implement protocols for the setting, resetting, and the noting and acceptance of alarm conditions raised by any gas monitoring system in use at the mine. In particular, such protocols should define: who is authorized to set or change alarm levels and the recording of those settings or changes; who is responsible for the acknowledgment of alarms and recording of acknowledgments; who is responsible for communicating the occurrence of alarms and initiating action as a result of those alarms; and how the actions of responsible persons, and the identity of those persons, are to be recorded. [Moura Page 68]
	It is recommended that all mines be required to develop and implement a spontaneous combustion management plan along the lines outlined to provide effective long term control of that risk and which satisfies any requirements of the Chief Inspector of Coal Mines as a condition for continued operation of the mine. [Moura Page 62]
	In respect of the design, installation and maintenance of seals, the Inquiry recommends that: the location of final seals be subject to approval by the District Inspector of Mines; it be a requirement that seals be constructed using only materials that have been approved for the purpose by the Chief Inspector of Coal Mines; and the Chief Inspector of Coal Mines should determine and then apply requirements appropriate for the design and installation of seals and for their long term stability. [Moura Page 69]
	It is for these reasons that the Inquiry further recommends that it be a requirement that no part of a mine be sealed without the prior written approval of the District Inspector of Mines (other than in an emergency, whereupon the inspector must be informed as soon as practicable thereafter). [Moura Page 69]
1997	Workers should be removed from any area in a mine where the concentration of dust or noxious gases in the air exceeds the standards set out by the

	American Conference of Governmental Industrial Hygienists (ACGIH). [Westray Page 278]
	Dust samples should be taken at least once a week using a method approved by the regulator for that purpose. Samples should be taken according to a regularly updated and approved plan. The regulator may require additional testing and may grant exemptions, providing that the overall safety of underground workers is not compromised. [Westray Page 350]
	The mine operator should provide suitable testing and calibrating facilities on the mine surface. Methanometers should be tested for accuracy before each shift and calibrated as required. [Westray Page 313]
	If the methane level in the area reaches or exceeds 1 per cent by volume, any electrically operated equipment in use should be shut down, and any shot firing being carried out should be discontinued: In addition to other safety devices, any electrical equipment operating at the mine face or in reasonable proximity, as established by the regulator, should be equipped with a methane monitoring device capable of continually monitoring the methane content of the air; If the methane content exceeds 1 per cent by volume, the methane monitoring device should automatically shut down the electrical equipment; The electrical equipment should not be re-energized until a qualified person certifies that the methane content in the air has been diluted to a safe level. (30 CFR sets out this requirement as it applies to mines under the jurisdiction of the U.S. Mine Safety and Health Administration.); The methane monitors installed on electrical equipment should be kept operative at all times and tested weekly for accuracy. Sensors should be affixed to the equipment as close to the working face as practicable. [Westray Page 313]
	Each crew at the working face of a mine should include a person trained in the use of a methanometer. This person should carry, while in the mine, an approved device or devices capable of testing for both methane and oxygen, and capable of testing at the roof and in roof cavities for layering. [Westray Page 313]
	The operation of mobile diesel-powered equipment underground should be regulated to ensure that the health and safety of the workforce is not endangered or impaired by such operation. [Westray Page 314]
	The mine operator should employ or retain the services of a qualified ventilation engineer to assist in the preparation of all ventilation plans or amendments to such plans. The ventilation engineer should sign any ventilation plans or amendments before they are submitted to the regulator. [Westray Page 277]
	The level of methane in an air intake to the working face of the mine should not exceed 0.5 per cent by volume: If the methane level exceeds 0.5 per cent by volume, the ventilation technician or other qualified person must take steps to adjust the ventilation system to dilute the methane to acceptable levels; If the methane level in any part of a mine reaches or exceeds 2 per cent by volume, all workers must be evacuated from the affected area; The airflow throughout the mine, including the mine face, should be such that methane will be diluted to a level below 0.5 percent by volume, as measured at least 30 cm from the roof or ribs; The velocity of air throughout the mine should be sufficient to prevent the formation of methane layers. [Westray Page 313]
	The overriding principle in mine ventilation must be that the mine is properly ventilated at all working times. It is the primary duty of the mine manager to ensure this proper ventilation: All active working places should be ventilated by a current of fresh air containing not less than 19.5 per cent by volume of oxygen and not more than 0.5 per cent by volume of carbon dioxide; and Each working face should receive fresh air of sufficient volume and velocity to dilute and render harmless all noxious or flammable gases and maintain all working and travelling areas in a safe and fit condition. [Westray Page 276]
	No mine should start up without a comprehensive ventilation plan approved by the regulator. The ventilation plan should be subject to at least an annual update, and any changes in the interim should be subject to approval by the regulator. [Westray Page 276]
	The ventilation plan should contain details of the system proposed, or of amendments to the existing approved system, and should indicate: the limits of the mine property and any adjacent workings, as well as any abnormal conditions; the location and detailed specifications of all surface fans and all surface openings; the direction, velocity, and volume of air at each mine opening; all underground workings, including location of all stoppings, overcasts, undercasts, regulators, doors, and seals; the method of sealing worked-out areas, provisions for air sampling behind any such seals, and the manner in which such sealed areas will be vented into return air passages (ensuring that no intake air is or could be passing any sealed-off area); the

	location of all splits and the volume of fresh air entering each split and of return air at each cross-cut in a room-and-pillar mine and at each working face; and the locations for the measurement of air in the mine to ensure the proper ventilation at all times. [Westray Page 276]
	The regulator may submit plans or amendments to a qualified mine ventilation engineer for review, and any fee for such review should be the responsibility of the mine operator. The regulator may require modifications to the plan in the interests of safety. [Westray Page 277]
	The regulator, in consultation with a qualified ventilation engineer, should draft regulations dealing with main fans and auxiliary fans. These regulations should include: details of the design, installation, operation, maintenance, and inspections of such fans; and requirements for instrumentation, the recording of data from such instrumentation, and the filing of this data with the regulator. [Westray Page 277]
	No booster fan should be installed underground without the approval of the regulator. [Westray Page 277]
	Every main ventilating fan should be mounted above ground in a fireproof fan house located at a safe distance from any mine opening and offset from any such openings or connections. The fan house should be equipped with a weak wall or explosion door located in a direct line with any possible explosion forces. Every main fan should be equipped with an audible alarm that sounds automatically if the fan stops or slows down. [Westray Page 277]
	Where any fan used in ventilating a mine stops for any reason, the area affected should be immediately evacuated. No auxiliary fan should be restarted until a qualified person has inspected the area and found it to be safe and free of gas. The area should not be re-entered until the ventilation has been restored to the required level and the area has been found to be safe and free of gas by a qualified person. If any fan remains stopped for more than 30 minutes, the mine operator should report the relevant circumstances to the regulator. [Westray Page 277]
	The regulator, in consultation with a qualified ventilation engineer, should draft regulations dealing with requirements for ducting, brattice, stoppings, locations of measuring devices, and sealing of abandoned sections of the mine. All brattice cloth, ducting, and materials used for constructing stoppings should be of fire-resistant material. [Westray Page 277]
	Equipment used to ventilate an underground coal mine should be of a type approved by the regulator and should be installed in an approved manner. Equipment, materials, or procedures not previously approved may be approved if the regulator is satisfied that the same measure of protection is provided to the underground worker. [Westray Page 277]
	Unless specifically approved in writing by the regulator, no more than one mechanized coal mining unit should operate in each ventilation split. Each split should be provided with a separate supply of fresh air. [Westray Page 278]
	Ventilating air should not be recirculated without the written consent of the regulator. [Westray Page 278]
	The mine operator should employ a qualified mine ventilation technician to be responsible for the operation and maintenance of the ventilation system. The ventilation technician should measure the airflow and sample the air quality in the mine at approved intervals of at least once a month for the whole mine and weekly for working areas. The results of ventilation and air quality tests should be recorded and a copy of such record should be filed with the regulator. [Westray Page 278]
	Devices used for testing air quality, velocity, and volume should be of a type certified and approved for such use by the Canada Centre for Mineral and Energy Technology (CANMET), the Approval and Certification Center of the Mine Safety and Health Administration (MSHA), the Canadian Standards Association (CSA), or other such equivalent testing body. [Westray Page 278]
	The regulator may require, as part of the mine development plan, a plan for the installation of a remote system for monitoring the mine atmosphere, with appropriate audible alarms and recording devices. Such a monitoring plan should include the provision that a qualified person must be at the remote monitoring station at all times that the mine is operating. [Westray Page 314]
2006	Mine ventilation systems must be designed to offer miners the greatest possible protection to enhance their ability to escape. Air used to ventilate seals must be coursed away from working sections, and immediately to the return. This is necessary to ensure that the integrity of the intake escape ways are not compromised. [Sago Page 11]
	In addition to the recommendations already made in this report and the MINER Act, MSHA must immediately take the following actions: Repeal the belt-air regulation; Require flame resistant conveyor belts in all mines; Move to increase the number and skill level of mine rescue teams; Lower the

	maximum exposure limit for respirable coal mine dust and silica; Update and expand training and retraining of miners; Develop a public hearing-style investigation process; Update the penalty and assessment scheme; Modify the conferencing process; Improve the certification and approval process; Assist NIOSH in developing the next generation SCSRs; Update permissible exposure limits for contaminants in the mine environment; Improve atmospheric monitoring systems; Develop a nationwide emergency communications system; Develop air quality, chemical substances and respiratory protection standards; and Address issues related to working in confined spaces. [Sago Page 17]
	The use of Omega Blocks should not be permitted as a ventilation control in any underground mining operation. [Sago Page 8]
	The agencies should not approve ventilation plans that utilize blowing ventilation where active working areas are inby. [Sago Page 9]
	The Union calls for the immediate and permanent ban on the use of all Omega or similar-type blocks and material in any underground area of all coal mines. [Sago Page 10]
	The Union believes the current protocol used for testing and approving seals is flawed. The National Institute of Occupational Safety and Health (NIOSH) recently issued a draft report entitled "Explosion Pressure Design Criteria for New Seals in U.S. Coal Mines." The report addresses two critical issues: What explosion pressures can develop during an explosion within a sealed area, and What are the appropriate design criteria for seals that will withstand these pressures? [Sago Page 10]
	MSHA should rescind its regulation that permits alternative materials and methods for constructing seals, and immediately require that all seals be explosion-proof seals or bulkheads, as is required by Section 303(y)(2) and (3) of the Federal Mine Safety and Health Act of 1977.[Sago Page 10]
	The agencies should consider future sealing methods that require approval of smaller, more manageable areas of the mine. These smaller sequentially sealed areas will eliminate large areas where enormous volumes of explosive gases can accumulate, allowing better control within the area. Successively sealing these areas will afford additional protections to miners. [Sago Page 9]
	Inspections of the construction of seals must be conducted by a certified engineer. The inspection must include monitoring the construction for a sufficient time, as well as evaluating the completed seal, to insure each seal is properly installed. The certified engineer should record the findings in an appropriate book. [Sago Page 8]
	The regulatory agencies should routinely inspect the seal during the construction and at the completion of each seal. Sufficient time for this inspection must be permitted to determine that all seals are properly constructed. [Sago Page 8]
	The National Institute for Occupational Safety and Health (NIOSH) recently released a draff report entitled, "Explosive Pressure Design Criteria for New Seals in U.S. Coal Mines." The UMWA fully endorses the report and its recommendations, as follows: For unmonitored seals where there is a possibility of methane-air detonation behind the seal, seals should be designed and built to withstand a pressure of 640 psi; For unmonitored seals with little likelihood of detonation, seals should be designed and built to withstand a pressure of 120 psi; For monitored seals where the amount of potentially explosive methane-air is strictly limited and controlled, seals should be designed and built to withstand a pressure of 50 psi, if monitoring can assure that the maximum length of explosive mix behind a seal does not exceed 15 feet and that the volume of the explosive mix does not exceed 40 percent of the total sealed volume. [Sago Page 8]
	The method of seal construction submitted by the operator in the ventilation plan and approved by the agencies must include: Seals must be hitched into the ribs and bottom a minimum of 6 inches; A method to continually monitor the atmosphere inby the seals from a remote location on the surface; Sealed areas must be treated as an integral part of the mine's overall ventilation system, and be specifically designed and approved for each installation at each mine. The seal requirements must be based on several factors, including area to be sealed, special conditions within the area to be sealed and methane liberation; and Seals must be constructed of solid, incombustible material as prescribed in the 1977 Mine Act. [Sago Page 8]
	The agencies should no longer permit areas of the mine that are sealed to self-inert without continuous monitoring as recommended by NIOSH. [Sago Page 8]
	Areas of the mine that are to be sealed must be free of all debris that is not permanently installed during the mining process. Materials and supplies such as unused roof support material, posts, oil and hydraulic containers, cables, equipment, belt structure, message or other cables and electrical components or cables must be retrieved and placed in a safe area outside the seals. [Sago Page 8]

	Seals in worked-out or abandoned areas of the mine should be visually inspected and tested each shift with an approved methane detector to insure their structural integrity and to check for methane leakage. [Sago Page 9]
	Seals that do not pass this inspection must be immediately leak-tested utilizing the same methodology currently used for this purpose at NIOSH's Lake Lynn experimental mine. Any leaks or damage to the seal must be repaired immediately. [Sago Page 9]
2011	Mine operators should be required to adopt computer-based monitoring of air quality, quantity and direction of flow throughout a mine. A suitable system would alert not only the mine operator and miners to impending danger, but it would also alert the state and federal regulatory agencies. Regulatory agencies would have the authority to shut down an operation based on data provided by the system. [Upper Big Branch Page 110]
	Current monitors for methane, carbon monoxide and coal dust must be upgraded to include memory chips, as well as instant communication to the communications center. [Upper Big Branch Page 110]
	Operators must be required to use real-time continuous monitoring for explosive methane gas and respirable dust in coal mines. [Upper Big Branch Page 110]
	Mine operators should be required to install equipment, such as seismographs, to monitor geologic activity at or near their mining operations. [Upper Big Branch Page 110]
	Electronic records should be maintained regarding methane, intake and return air levels on all coal producing sections for no less than seven years. Had this information been available, investigators would have had data related to the previous methane inundation at UBB. [Upper Big Branch Page 110]
	WVMHST, NIOSH, MSHA and the mining industry should adopt before the end of 2011 rules to: reduce the permissible exposure limit (PEL) for coal mine dust to 0.09 mg/m; reduce the PEL for crystalline silica to 0.05 mg/m; and mandate continuous dust monitoring, verification of mine operators' dust control plans at normal production (e.g., at least equal to the average production recorded for the most recent 30 production shifts), and single-shift sampling. [Upper Big Branch Page 113]
	WVMHST and MSHA should undertake reorganization on their ventilation approval system to ensure that plans and requirements are known and understood by both the ventilation specialists as well as the inspectors. [Upper Big Branch Page 109]
	Specifically use a "pattern of violation" and/or "flagrant violation" authority for violations of key standards designed to prevent explosions, and apply meaningful sanctions, such as revoking the operator's ventilation plan. If an operator's plan is revoked for reckless or repeated behaviour, he should be offered a brief period of time (e.g., five days) to make the safety case to MSHA as to why the mine's ventilation plan should not be revoked. [Upper Big Branch Page 109]
	A procedure should be adopted that would require mine operators repeatedly cited for failing to follow their own approved ventilation plan to notify MSHA and WVMHST when subsequent ventilation changes are completed and before miners are allowed back underground. Affected miners would be entitled to full compensation by the operator at their regular rates of pay and work schedule for the entire period they are idled. [Upper Big Branch Page 109]
2015	The Ministry of Labour and the relevant Health and Safety Associations to increase their capacity to ensure the health and safety system has the resources to address mining hazards effectively – particularly the priority hazards identified in the risk-ranking exercise. In particular: Increase ministry capacity in geotechnical, mining, mechanical, electrical, structural, and civil engineering; and Increase system partners' technical capacity/ resources related to industrial hygiene and mechanical issues. [Mining Review Page 53]
	The Ministry of Labour to review existing occupational exposure limits for a number of key airborne and chemical hazardous substances in underground mines with a view for giving further consideration to the limits for those substances and, if appropriate and advisable, amend Regulation 833. Priority to be given to a review of the occupational exposure limits for silica, nitrogen dioxide and diesel particulate matter (DPM). Other hazards to be considered include: sulfur dioxide, and radon. [Mining Review Page 30]
	The Ministry of Labour to require employers in the mining sector to conduct risk assessments, which would include measures and procedures to control the risks identified in the assessment as likely to expose a worker to injury and illness. The joint health and safety committee, health and

	safety representative, union or workers be consulted on the risk assessment. Employer risk reassessments are to be done as often as necessary to ensure programs that result from the assessment continue to protect workers. [Mining Review Page 29]

APPENDIX 5B Recommendations pertaining to the Ontario Mine Rescue Technical Advisory Committee Current Projects.

Team Communication	
2006	Current communication technology, including one-way text messaging and two-way wireless systems, must be immediately installed in all mines. Any system that can increase the ability for miners to escape a mine emergency, even if it is limited in scope, must be utilized. [Sago Page 11]
	Communications with family members, the press and general public should be handled by an independent arm of the federal government, much like the National Transportation Safety Board (NTSB) and Surface Transportation Board (STB) do with air, rail or highway incidents. They should also make necessary arrangements for family members as they arrive at the site. These requirements should be specifically laid out in the mine emergency response plan. [Sago Page 15]
	Information from the command center to any sources not immediately involved in the rescue efforts should be carefully monitored and verified to ensure accuracy. In the event miscommunications occur, they must be immediately corrected. [Sago Page 15]
	The federal and state agencies should be responsible for immediately notifying and deploying all government rescue personnel, equipment and other necessary assets to the mine site after being notified that an emergency situation exists. [Sago Page 14]
	Every effort should be made to coordinate the emergency response of the federal, state and local agencies. [Sago Page 14]
	All mobile equipment entering the mine during rescue and recovery efforts must be equipped with two- way communications. [Sago Page 15]
2011	Immediate implementation of a computerized, real-time electronic personnel-recording system to formally identify and locate all personnel who are underground at a given time, including supervisory personnel. Redefine the state and federal regulations to ensure that no one, including management, goes underground without a tagging device. [Upper Big Branch Page 110]
	Mine operators' emergency response plans (ERPs) must be treated more than just more paperwork. ERPs should be developed collaboratively with miners, their families, local responders, and mine rescue team members, and revised based on mine-specific drills and table-top exercises. [Upper Big Branch Page 112]
	A coordinated, formal debriefing of all mine rescue team members who respond to a major mine emergency should be conducted within a month of the event. The objectives of the assembly would include offering counsel on post-traumatic stress, discussing what worked well and what didn't in their mine emergency response, and identifying team members whose testimony would be helpful to accident investigators. [Upper Big Branch Page 113]
	The mine rescue community should convene a summit of mine rescue team members, in particular, individuals who responded to the mine emergency incidents from 2006 to the present, to discuss the state of the U.S. mine rescue system. Advisory guidelines should be written for mine rescue teams. [Upper Big Branch Page 112]
	Protocols should be established and followed with regard to mine rescue and recovery, using lessons learned and best practices identified from other emergency response events. [Upper Big Branch Page 112]
	MSHA and West Virginia should require a digital recording of the activities and communications in a mine emergency command center. Briefings and debriefings of mine rescue team personnel also should be recorded. The current paper and pencil method fails to produce a thorough record of key data and decision points. Such a record is necessary to conduct a thorough investigation, assess the effectiveness of existing mine rescue operations and contribute to training curriculum for advanced mine rescue personnel. [Upper Big Branch Page 112]
2012	Emergency management in underground coal mines needs urgent attention: Operators of underground coal mines should be required by legislation to have a current and comprehensive emergency management plan that is audited and tested regularly; The emergency management plan should be developed in consultation with the workers and the Mines Rescue Service; The emergency management plan should specify the facilities available within the mine, such as emergency equipment, refuges and changeover stations, and emergency exits; The emergency management plan should contain a strategy for notifying next of kin and ensuring that genuine enquirers receive appropriate information; The mining operator must keep and regularly update a comprehensive list of emergency contact details for all workers; The emergency management plan needs to be compatible with

	CIMS, the co-ordinated incident management system used by New Zealand's emergency services and the police; and The regulator should include the emergency management plan in its audit programme. [Pike River II Page 354]
	The implementation of the co-ordinated incident management system (CIMS) in underground coal mine emergencies should be reviewed urgently: The implementation of CIMS should be reviewed to ensure that emergencies in underground coal mines are well managed; The review team should include the mining industry, police, emergency services, the Mines Rescue Service and the regulator; The CIMS framework should be rigorously tested by regular practical exercises at underground coal mines; and The incident controller at an underground coal mine emergency must have mining expertise and, together with the incident management team, must be responsible for co-ordinating the emergency effort and approving key decisions. This does not prevent a government agency such as the police from being the lead agency or from maintaining its command structure. [Pike River II Page 354-355]
2015	The Ministry of Labour to work with stakeholders to develop proposed recommendations regarding the responsibilities of mine rescue crew members and mine owners/employers, with respect to mine rescue operations. [Mining Review Page 40]
Competency Based Training	
1986	That the Ministry of Labour, with the assistance of the Mining Legislative Review Committee, draft comprehensive first-aid regulations with specific reference to underground mining operations. [Ground Control & Mine Rescue Page 63]
2006	Training for SCSR donning and escape must be wholly separate from all other types of training miners currently receive. This training must be repeated every 90 days. [Sago Page 12]
	Training for mine rescue teams should be required frequently, but at least every quarter (three months). Training should be done at each mine the rescue team is charged with covering. This will require surface as well as underground exercises to ensure the team members are familiar with the facility. [Sago Page 16]
	Mine rescue teams should be certified by MSHA to ensure competence. Certification should be directly tied to the team's demonstrating proficiency and skill in all aspects of mine rescue. Teams that do not pass the certification may continue to practice, but shall not be permitted to perform any actual mine rescue. [Sago Page 16]
	SCSR and escape training must be done in actual conditions underground and, to the extent possible, reflect real-life emergency situations. Miners must don the SCSR training model and walk at least a portion of the escapeway. [Sago Page 12]
	All mine rescue teams should be required to participate in at least two mine rescue contests every year. Failure to participate must result in the team's certification being revoked. [Sago Page 16]
2011	SCSR training should be conducted quarterly, instead of annually. [Upper Big Branch Page 113]
	SCSR training should be realistic and conducted in actual mining situations, such as riding in a man trip and working on a longwall. It should incorporate a variety of actual in-mine scenarios for which the SCSR must be donned and activated. The training should emphasize the importance of activating the SCSR at the very first warning of an emergency. [Upper Big Branch Page 113]
Refuge Station Design	
1986	That manway sizes, escape routes and refuge stations be sufficient to accommodate rescue operations. [Ground Control & Mine Rescue Page 63]
2006	Mine ventilation systems must be designed to offer miners the greatest possible protection to enhance their ability to escape. Air used to ventilate seals must be coursed away from working sections, and immediately to the return. This is necessary to insure that the integrity of the intake escapeways are not compromised. [Sago Page 11]
	All mandoors must be clearly marked on both sides. [Sago Page 11]
	"Safety chambers" and "safe havens" should be required in all mining operations. The Union notes that these are two distinct systems and they cannot be used interchangeably. [Sago Page 13]
2012	To support effective emergency management, operators of underground coal mines should be required to have modern equipment and facilities:

	Operators should be required to have equipment and facilities suitable for self-rescue by workers during an emergency; Operators should be required to include, in their emergency management plans, provisions for continued monitoring of underground atmospheric conditions during an emergency; and Operators should be required to install facilities that will support emergency mine sealing and inertisation. [Pike River II Page 365]
Emergency Response Risk	
1997	Every community at or near which underground mining operations are carried out should have a plan to provide emergency medical, fire, and other support services. The plan should include providing emergency training to the appropriate people in those communities. Some familiarity with the underground environment could be helpful in the event of a disaster. [Westray Page 561]
	Rescue and emergency equipment should be standardized so that those persons trained in rescue procedures will be completely familiar with the equipment available. Similarly, the various testing devices should be standardized so that the rescuers are able to use these devices without losing valuable time and without the danger of mistaken or inaccurate readings. [Westray Page 561]
2006	MSHA and NIOSH must update and test new, easily deployable, reliable and accurate seismic- type devices to locate trapped miners. At least one of these devices should be maintained in each MSHA District office. [Sago Page 13]
	Flame-resistant reflective directional lifelines must be required from the face areas in both the primary and secondary escapeways. These lifelines should direct miners from their workplace to the nearest surface escape, shaft, slope or capsule. [Sago Page 11]
	Flame-resistant directional reflective lifelines must intersect every oxygen storage location in the escapeway. [Sago Page 12]
	Tethers for linking miners together when necessary during escape should be available in every section at the inby end of the lifeline. They should be of sufficient length to eliminate the possibility that miners will become entangled while they are walking or crawling to safety. Additional tethers should be located at strategic locations throughout the mine. [Sago Page 11]
	New SCSRs should be positive-pressure units with full face masks. [Sago Page 12]
	Additional oxygen devices must be readily available where miners are working to ensure there is an adequate supply to begin an escape in an emergency situation. Oxygen must be available for all miners to effectively escape from the deepest penetration of the mine to the surface. [Sago Page 11]
	Additional oxygen devices in protective cases must be stored at strategic locations in both the primary and secondary escape ways for miners to access as they travel out of the mine. These caches must be placed at a distance not to exceed 30 minutes normal walking distance. [Sago Page 11-12]
	SCSR storage caches should include a communication system to the surface, first aid supplies and tethers as well as oxygen. [Sago Page 12]
	The agencies must immediately take enforcement action against any operator that does not comply with the mine rescue team requirements. This action should include issuance of a closure order that stops production at all affected operations. Facilities so affected should not be permitted to resume operations until all aspects of the mine rescue team requirements are met. [Sago Page 16]
2011	MSHA and NIOSH should develop an approved rescue vehicle for removing injured miners safely from the mines. State and federal agencies should have a vehicle for removing injured miners and victims from a mine in a safe and efficient manner. Rescue workers should not have to carry miner's great distances underground. [Upper Big Branch Page 110]
2015	Workplace Safety North to revise the Mine Rescue Handbook to include guidelines for fitness of crew members, critical incident stress management and acclimatization of emergency responders. [Mining Review Page 40]

APPENDIX 5C Recommendations demonstrating overlap with the new Mining Health Safety and Prevention Review Recommendations.

		1967	1976	1981	1986	1995	1997	2006	2011	2012
Health & Safety Hazards	**1.1**	The Ministry of Labour supported by all relevant health and safety system partners and subject matter experts, to undertake a Mining Sector Risk Assessment with employers and labour every 3 years.								
	1.2	The Ministry of Labour to require employers in the mining sector to conduct risk assessments, which would include measures and procedures to control the risks identified in the assessment as likely to expose a worker to injury and illness. The joint health and safety committee, health and safety representative or workers, be consulted on the risk assessment. Employer risk reassessments are to be done as often as necessary to ensure programs that result from the assessment continues to protect workers.								
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	1976	That the Occupational Health and Safety Authority be given by statute the authority and responsibility to conduct a full and expeditious review of any emergent situation in which the health and safety of workers in mines are believed to be at unexpected risk [Royal Commission Page 78]								
	1.3	The Ministry of Labour to work with its Research Advisory Council to focus its grants and research on topics that address the priority hazards identified in the Mining Sector Risk Assessment, and disseminate and act upon the findings where appropriate. In particular, the Review identified several research opportunities: • Defining the scientific basis for de-stressing practices and developing guidance materials that define best practices for de-stressing • Exploring options for collaborating with technology developers to mitigate risks associated with seismicity and rock bursting (i.e. similar to the Australian Centre for Geomechanics model) • Defining and quantifying the harmful health and safety effects of worker fatigue in the Ontario Mining Sector, and researching other sectors (e.g. transportation, health care and the military) to see how the mining sector compares, and how the problem has been managed.								
	1.4	The Mining Legislative Review Committee to align the majority of its work with the major hazards identified in the sector level risk assessment exercise.								
	1.5	The Ministry of Labour to require that mining employers to address the priority hazards identified in the risk ranking exercise: • Enhance ground control protection by identifying key elements in the control of these hazards and requiring employers to maintain a record of significant seismic events in addition to incidents of ground instability • Require employers to prepare a formal plan to manage hazards that cause occupational illness, including requirements for worker and supervisor training and communication • Require all underground mines employers to have in place a formal water management program • Specify that precautions be taken by employers to guard against the accumulation of water in bins, ore and waste passes and chutes • Require all underground mines to have in place a formal traffic management plan.								
	1.6	The Ministry of Labour to review existing occupational exposure limits for a number of key airborne and chemical hazardous substances in underground mines with a view for giving further consideration to the limits for those substances and, if appropriate								

		and advisable, amend Regulation 833. Priority to be given to a review of the occupational exposure limits for silica, nitrogen dioxide and diesel particulate matter (DPM). Other hazards to be considered include sulfur dioxide, and radon.
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	1976	That where more than one recognized toxic component is present in the aerosols the standard specify how an effective combined exposure limit is to be determined [Royal Commission Page 53]
		That tests using sputum cytology be conducted every two years on all persons who have worked in radiation exposure at the uranium mines for five or more years [Royal Commission Page 108]
		That the Atomic Energy Control Board review the basis for and issue explicit regulations establishing the maximum permissible annual exposure to ionizing radiation for workers in uranium and thorium mines and mills [Royal Commission Page 86]
		That the regulations for maximum permissible exposure delineate how all significant components of external and internal irradiation are to be accounted for and indicate how total exposure and related dose is to be evaluated [Royal Commission Page 86]
		That the regulations for maximum permissible exposure and related dose be interpreted in units that can be monitored by practical means in uranium and thorium mines and mills [Royal Commission Page 86]
		That the Province of Ontario, through the Occupational Health and Safety Authority, establish by statute a standard for maximum permissible annual exposure to ionizing radiation for workers in uranium and thorium mines and mills, and that this standard be in conformity with the regulatory standards of the Atomic Energy Control Board [Royal Commission Page 87]
		That the Mines Inspection Branch prepare regulations defining the kinds and frequencies of measurements of ventilation, dust and radiation necessary to enable it to audit the engineering operational characteristics of uranium and thorium mines and mills [Royal Commission Page 88]
		That these regulations be in conformity with the related code of guidance established by the Atomic Energy Control Board [Royal Commission Page 88]
		That the Occupational Health and Safety Authority specify: a level of radiation in mine or mill air measured at any time in any occupied workplace which, if exceeded, requires that corrective action be taken immediately; and a level of radiation in mine or mill air measured at any time in any occupied workplace which, if exceeded, requires closure of the related workplace until the level of radiation is reduced below that specified in 1 [Royal Commission Page 88]
		That job rotation within mines conducted to meet the standard for maximum permissible annual exposure to ionizing radiation be permitted only in exceptional circumstances with the explicit approval on a case-by-case basis of the Occupational Health and Safety Branch and with the knowledge of the representatives of the workers [Royal Commission Page 105]
	2011	WVMHST, NIOSH, MSHA and the mining industry should adopt before the end of 2011 rules to: reduce the permissible exposure limit (PEL) for coal mine dust to 0.09 mg/m; reduce the PEL for crystalline silica to 0.05 mg/m; and mandate continuous dust monitoring, verification of mine operators' dust control plans at normal production (e.g., at least equal to the average production recorded for the most recent 30 production shifts), and single-shift sampling. [Upper Big Branch Page 113]
New Tech. & Management of Change Process	**2.1**	The Ministry of Labour to require mine operators to establish and implement a written management of change procedure, to include workers and the joint health and safety committee or health and safety representative.

Emergency Preparedness & Mine Rescue	**3.1**	The Ministry of Labour to require mining companies to conduct risk assessments to establish Emergency Response Plans for exploration sites, new mines, surface mines and mining plants.
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	1995	It is recommended that mines be required to put in place Mine Safety Management Plans to cater for key risk areas. [Moura Page 62]
		It is further recommended that Mine Safety Management Plans be based on detailed risk/hazard analyses. [Moura Page 62]
	1997	Every mine operator, indeed, every industrial plant or facility, should have a well-defined and comprehensive emergency procedures manual containing a complete and up-to-date list of all persons involved in any emergency operation. This list should contain an organization chart listing the individuals and their respective tasks, and a current telephone listing for each person. The manual should be prepared by the company in consultation with both the joint occupational health and safety committee and the safety coordinators with the appropriate government departments. The manual should set out, in detail, the quantity and location of all emergency supplies and equipment and the details of the deployment of these materials. A current copy of any such approved emergency procedures manual should be filed with the director of occupational health and safety, and copies should be provided to each person assigned any duty under the manual. [Westray Page 560]
		The Department of Labour, in consultation with the operator, should establish such rules and regulations that would ensure the department a full and active role in every mine-related emergency procedure or rescue operation in the province. The rules and regulations should set out the duties and responsibilities of each department inspector or safety examiner in any mine-related emergency or rescue operation. [Westray Page 561]
	2011	Mine operators' emergency response plans (ERPs) must be treated more than just more paperwork. ERPs should be developed collaboratively with miners, their families, local responders, and mine rescue team members, and revised based on mine-specific drills and table-top exercises. [Upper Big Branch Page 112]
	2012	Emergency management in underground coal mines needs urgent attention: Operators of underground coal mines should be required by legislation to have a current and comprehensive emergency management plan that is audited and tested regularly; The emergency management plan should be developed in consultation with the workers and the Mines Rescue Service; The emergency management plan should specify the facilities available within the mine, such as emergency equipment, refuges and changeover stations, and emergency exits; The emergency management plan should contain a strategy for notifying next of kin and ensuring that genuine enquirers receive appropriate information; The mining operator must keep and regularly update a comprehensive list of emergency contact details for all workers; The emergency management plan needs to be compatible with CIMS, the co-ordinated incident management system used by New Zealand's emergency services and the police; and The regulator should include the emergency management plan in its audit programme. [Pike River II Page 354]
		The implementation of the co-ordinated incident management system (CIMS) in underground coal mine emergencies should be reviewed urgently: The implementation of CIMS should be reviewed to ensure that emergencies in underground coal mines are well managed; The review team should include the mining industry, police, emergency services, the Mines Rescue Service and the regulator; The CIMS framework should be rigorously tested by regular practical exercises at underground coal mines; and The incident controller at an underground coal mine emergency must have mining expertise and, together with the incident management team, must be responsible for co-ordinating the emergency effort and approving key decisions. This does not prevent a government agency such as the police from being the lead agency or from maintaining its command structure. [Pike River II Page 354-355]
	3.2	Workplace Safety North to revise the Mine Rescue Handbook to include guidelines for fitness of crew members, critical incident stress management and acclimatization of emergency responders.

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	2006	Steps must be taken immediately to significantly increase the number of qualified mine rescue teams nationwide. [Sago Page 16]								
		Composite and contract mine rescue teams should not be permitted under any circumstances. [Sago Page 16]								
	2011	A coordinated, formal debriefing of all mine rescue team members who respond to a major mine emergency should be conducted within a month of the event. The objectives of the assembly would include offering counsel on post-traumatic stress, discussing what worked well and what didn't in their mine emergency response, and identifying team members whose testimony would be helpful to accident investigators. [Upper Big Branch Page 113]								
		The mine rescue community should convene a summit of mine rescue team members, in particular, individuals who responded to the mine emergency incidents from 2006 to the present, to discuss the state of the U.S. mine rescue system. Advisory guidelines should be written for mine rescue teams. [Upper Big Branch Page 112]								
		Protocols should be established and followed with regard to mine rescue and recovery, using lessons learned and best practices identified from other emergency response events. [Upper Big Branch Page 112]								
	3.3	The Ministry of Labour to work with stakeholders to develop proposed recommendations regarding the responsibilities of mine rescue crew members and mine owners/employers, with respect to mine rescue operations.								
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	1981	That the Mines Accident Prevention Association of Ontario sever its ties with the Ontario Mining Association, retain the services of a full-time executive director, establish its own offices separate and apart from the Ontario Mining Association offices, make provision tor its own support staff and services, and continue to be financed by levies against its member companies. [Towards Safe Production Page 231]								
		That the Mines Accident Prevention Association of Ontario establish labour-management advisory committees at both the provincial and regional levels and that it move to include representatives of labour and the public on its board of directors. [Towards Safe Production Page 232]								
	1986	That the current mine rescue organization be expanded to handle all underground emergencies. [Ground Control & Mine Rescue Page 63]								
	2006	MSHA must create a Mine Emergency Response Office (MERO) within the Agency. The MERO must be staffed 24 hours a day, seven days a week, by experienced full-time MSHA employees with extensive mining knowledge. Emergency contact to MSHA by mine management personnel should be available using a toll-free phone number. [Sago Page 14]								
		MSHA must take immediate control of all aspects of the rescue and recovery. It must create plans and implement them to facilitate the immediate use of all mine rescue assets as soon as possible. MSHA should exercise the authority mandated by Congress and not delay before implementing a plan to safely enter the mine and facilitate rescue activity. [Sago Page 15]								
		The mine operator must be on-site to provide logistical and general mine information necessary to facilitate rescue and recovery operations. [Sago Page 15]								
		The federal and state regulatory agencies must secure the surface area of the mine and limit access by individuals who have no right to enter the property or are not involved in the rescue efforts. This will ensure rescue teams, fire crews, police, miners' representatives and other necessary personnel understand their roles in the disaster response and are not delayed in beginning the rescue effort. [Sago Page 15]								
Training,	**4.1**	Enhance supervisor and management training by: • Requiring the Mining Tripartite Committee, which supports the development of Common Core training, to present to the								

Skills and Labour Supply Issues		Ministries of Labour and Training, Colleges and Universities options and recommendations to enhance supervisor and management health and safety training • Requesting the Mining Tripartite Committee to review the pre-requisites for Supervisor Common Core training and determine the best format for this training (e.g. classroom learning, hands-on experience).								
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	1981	That joint training tor members of joint health and safety committees be undertaken and where possible, supervisors also be involved. [Towards Safe Production Page 229]								
	1986	That health and safety committee members shall receive the same training in ground control as supervisory staff. [Ground Control & Mine Rescue Page 53]								
		That worker-inspectors, where they exist, be given the same training in ground control as that recommended for supervisory staff elsewhere in this report. [Ground Control & Mine Rescue Page 69]								
	4.2	The Ministry of Labour to engage in discussions with the Ministry of Training, Colleges and Universities about the quality and consistency of Common Core training in the underground mining sector, evaluate the current state of that training delivery and identify circumstances where refresher training may be appropriate.								
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	1986	That all miners receive periodic refresher courses in ground control if required. Labour shall be encouraged to participate in the development of the curriculum. [Ground Control & Mine Rescue Page 52]								
		That miners who have been off the job for one year or more should be evaluated with respect to their knowledge of current ground control practices, and should receive appropriate training where necessary before they return to regular underground work. [Ground Control & Mine Rescue Page 52]								
		That the mining industry in Ontario be encouraged to sponsor their employees' attendance at existing short courses and other programs as they become available. [Ground Control & Mine Rescue Page 56]								
		That these short courses be designed so that adequate training can be given in various locations, including remote regions of the province. [Ground Control & Mine Rescue Page 56]								
	1995	In particular, it is recommended that certificates not be granted for life and that a system needs to be developed and put into effect as soon as practicable that requires certificate holders to demonstrate their fitness to retain the certificate of competency on a regular basis, at intervals of not less than three and not more than five years. [Moura Page 64]								
	1997	The mine operator should be required to have in place a training program, approved by the regulator, for every position in the workplace. The mine operator's training proposal must: conform to or be more rigorous than the model curriculum; show when, how, and what training will be done; incorporate annual refresher training and safety education; provide for adequate orientation to the mine for all new employees, including those with experience in coal mines; and include complete and sufficient training for operators of individual pieces of mining equipment prior to their being assigned operating positions. [Westray Page 133]								
Capacity of the Occupational Health & Safety	**5.1**	The Ministry of Labour and the relevant Health and Safety Associations to increase their capacity to ensure the health and safety system has the resources to address mining hazards effectively – particularly the priority hazards identified in the risk- ranking exercise. In particular: • Increase ministry capacity in geotechnical, mining, mechanical, electrical, structural, and civil engineering • Increase system partners' technical capacity/ resources related to industrial hygiene and mechanical issues.								
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System	**1976**	That the Occupational Health and Safety Branch publish biennially a critical review of factors that influence risks of accident and injury at workplaces in the mines and mineral plants [Royal Commission Page 130]
	5.2	The Ministry of Labour to review its policies and procedures that apply to mining inspectors related to unannounced field visits, reprisals, repeat orders, the training of inspectors and the provision of information to workplace parties and how those policies and procedures are implemented. Take appropriate actions based on the findings of that review. In particular, address the following operational policies and procedures: • Clarify the use of unannounced proactive field visits • Clarify the appropriate use of orders versus other methods to achieve compliance for priority hazards especially with regard to repeated non-compliance with the same issue in a specific workplace • Clarify inspector action to be taken in situations of suspected reprisal • Align proactive activities, whenever possible, to the priority hazards identified in the sector level risk assessment • Clarify the training provided to inspectors to address priority hazards and the inspector's role in the inquest process • Identify any further training required to support changes in policies and procedures brought about by the Review and/or changes in the regulations.
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	1967	The ambit of the Mines and Quarries Act, 1954, is restricted by its long title to "the management and control of mines and quarries and for securing the safety health and welfare of persons employed thereat; to regulate the employment thereat of women and young persons; to require the fencing of abandoned and disused mines and of quarries; and for purposes connected with the matters aforesaid". Apart, therefore, from s. 151, which requires a disused mineshaft to be "provided with an efficient enclosure, barrier, plug, or other device so designed and constructed as to prevent any person from accidentally falling down the shaft," there is no requirement on the owners or manager of a mine to have regard to the safety of the general public. It follows that there is no obligation on the Inspectorate of Mines, in the exercise of its powers of securing the enforcement of the Act, to have regard to the safety of the general public. Indeed, s. 146 (1) which gives power to the Inspector to serve a notice for prohibiting or changing "any matter, thing, or practice at a mine" which "is or is likely shortly to become dangerous" repeats the limitation to the safety of persons employed at the mine. We recommend that this limitation in the Act be removed and that the owners and managers of mines, and also the Inspectorate of Mines, should be required to consider the safety, health, and welfare of all persons going about their lawful business in the vicinity of a mine, including the safety of their property. We have already indicated (ante paragraph 74) our view of the civil liability of mine owners to pay damages under the rule in Rylands v. Fletcher, but the disaster at Aberfan clearly indicates that substantially more is required to give that protection to the public which it is every citizen's right to expect. [Aberfan Page 129]
		Section 86 of the Mines and Quarries Act, 1954, ("All buildings and structures on the surface of a mine shall be kept in safe condition") should be amended so as to eliminate any doubt whether tips are "structures" within the meaning of the Section. [Aberfan Page 129]
		The existing Town and Country Planning Acts require to be amended so as to vest local planning authorities with greater control over the starting of new tips or the extension of existing ones. As to new sites, we favour the suggestion made by Sir Andrew Bryan that these should not be started until a report as to the suitability of the tipping scheme has been submitted to and approved by the planning authority. As to the continued use of an existing tipping site, we recommend that the General Development Order, 1963, be revised by adding to Col. (2) of Class XIX (3) a condition that such continued use after a given date (say, January 1st, 1969) be

		subject to the production of a similar report prepared by persons professionally qualified and satisfactory to the planning authority. If an impasse arises, the dispute should be submitted to the appropriate Minister and he should be vested with power to refer to an independent expert in the manner set out in paragraph 292 above. Provision should be made enabling the Minister to exclude, in a proper case, any claim for compensation if in the ultimate result permission to tip or to continue tipping is withheld or refused on grounds of safety. [Aberfan Page 130]
		Recommend adoption of, the suggestion made by Sir Andrew Bryan that the National Coal Board should prepare for consideration by the National Tip Safety Committee, with a view to its thereafter being issued publicly, a Code of Practice giving guidance on (a) features and factors that may give rise to or reveal instability in a tip, and (b) standards of safety called for in particular locations or circumstances. We attach in Appendix F Sir Andrew Bryan's suggestions as to the topics which should be covered by such a Code. But the vexed question remains: Within the National Coal Board itself, what organisation should in future be responsible for tip safety and stability ? We were told that during the Inquiry the lay-out of Board administration had been drastically altered, that Divisions and Groups had already been abolished and the whole country divided into 17 Areas, each headed by its own Area Director, and that the old South Western Division had become two Areas. And it was said in Parliament on June 6th last (Hansard Vol. 747, col. 173-4) that the Minister of Power had ascertained from the National Coal Board that, "A procedure has been established by the Board for technical and operational control over spoil heaps which includes frequent and regular investigations by specialists to ensure safety and stability". Furthermore, Mr. Wien, Q.C., told the Tribunal that in South Wales:".. . we have recently established a Tip Control Unit under the direction of Mr. Gareth Jones, the civil engineer, and he has got a complete team with independent experts to be consulted about old tips. They will give technical guidance to Areas on active tips or on the selection of new tips, and I daresay that when the Tip Safety Committee comes into existence this will be a matter that will be carefully considered by that Committee ... The Coal Board has been proceeding assiduously with training courses which have been held quite recently and all kinds of people (from Area Directors downwards, and including Area Civil Engineers from the rest of the country and Her Majesty's Divisional Inspector of Mines) have attended, dealing with tip stability. And in due course instruction will be given down to a very much lower level, to chargehands and foremen". When these assurances are implemented, the whole attitude in relation to tip stability should soon become dramatically altered. To ensure this, urgent consideration should be given to the appointment of civil engineers to the Inspectorate. [Aberfan Page 127]
	1976	That an Occupational Health and Safety Authority, encompassing the Mines Engineering and Inspection Branch, the corresponding branches under the Industrial Safety Act and the Construction Safety Act, and the Occupational Health and Safety Branch, be established in the Ministry of Labour under an assistant deputy minister [Royal Commission Page 254]
		That a Health and Safety in Mines and Plants Act, separate from the Mining Act, be prepared to replace part ix and the relevant sections of part xi of the Mining Act and be administered within an Occupational Health and Safety Authority established in the Ministry of Labour [Royal Commission Page 254]
		That the Health and Safety in Mines and Plants Act consist of a core of general provisions supplemented by regulations the issuance of which is authorized by the Act [Royal Commission Page 254]
		That under the Workmen's Compensation Act provision be made for the levying on all employers in class 5 an amount of 0.03 per cent of wages currently subject to levy under the Act to create a fund for research on occupational health and safety by the joint labour- management health and safety committees [Royal Commission Page 239]
		That Section 53 of the Workmen's Compensation Act be amended as necessary to provide clear entitlement for rehabilitative compensation based on the principle of work adjustment for persons subject to exceptional exposure to environmental hazards at work [Royal Commission Page 57]

	1981	That the Government of Canada incorporate by reference the Ontario Act and regulations, as amended from time to time, directly into the Canada Labour Code as a proviso covering uranium miners and plant workers, and also provide in the code that where the other provisions of the code and this provision arc in conflict, the latter shall apply. [Towards Safe Production Page 237]
		That the Government of Canada proceed by way of a reference to the Supreme Court of Canada by the Governor General in Council under section 55 of the Supreme Court Act. R.S.C. 1979 C S-19 and determine whether the federal jurisdiction is exclusive or concurrent. [Towards Safe Production Page 238]
		That the Governments of Canada and Ontario continue the arrangement under which the enforcement of statutory[1] health and safely requirements in Ontario uranium mines is assigned to provincial authorities. [Towards Safe Production Page 238]
	1995	It is recommended, therefore, that it be made a requirement of Part 60 (Second Working Extraction) submissions that spontaneous combustion be specifically included as a factor to be considered and evaluated. [Moura Page 72]
		The Inquiry recommends that the Act be amended to enable either proxy or alternative members to fill temporary or permanent positions on the panel or for an Inquiry to continue with a reduced number of panel members. [Moura Page 73]
	1997	The mandate of the Department of Natural Resources should be formally reviewed and clarified vis-a- vis the mandate of the Department of Labour to ensure that there are no gaps in the regulatory process. [Westray Page 404]
		The Mineral Resources Act should be amended to identify clearly the role of the Department of Natural Resources in monitoring mine planning in the province. Such a role should encompass the duty to make site inspections to ensure that an operator is mining in conformity with plans approved by the department. [Westray Page 405
		The Mineral Resources Act should be amended to identify clearly the role of the Department of Natural Resources in ensuring the "safe" operation of mines in the province. [Westray Page 405]
		The Occupational Health and Safety Act, 1996, should be revised to incorporate the following changes: Except in the case of a demonstrated emergency, any communication respecting health and safety concerns should go initially to the first-line supervisor. If the first-line supervisor is unable or unwilling to resolve the matter, then the complaint should be taken directly to a member of the joint occupational health and safety committee, for resolution by the committee as expeditiously as possible. Provisions should be adopted to clarify how interests of non-union employees in a union shop will be met on the joint occupational health and safety committee. No member of management whose principal duty or concern relates to production quotas should be eligible for membership on the joint occupational health and safety committee. No member of the executive of any employee organization or union, or any person who has served in such capacity within the preceding year, should be eligible for membership on the joint occupational health and safety committee. Provisions should be adopted to define clearly the health and safety obligations of employees to workers on site who are employed by contractors other than the principal employer. Those contractor employees should have obligations similar to those of the employees of the principal employer. For greater certainty, the terms "serious injury" and "bodily injury" should be replaced with the one term "serious injury," defined as any injury that requires immediate medical aid or hospitalization or renders the employee unable to perform his or her regular duties for a period in excess of 24 hours. [Westray Page 510]
		All rules and regulations relating to the operation of coal mines should be contained in Regulations made pursuant to the Occupational Health and Safety Act. The Coal Mines Regulation Act and the portions of the Mineral Resources Act dealing with operations should be repealed. [Westray Page 540]
		The province should take immediate action to reach agreement with the federal Department of Labour for the inspectorate of that department to assume the underground coal mine regulation and inspection functions currently under the aegis of the provincial

		Department of Labour. [Westray Page 542]
		The province should collaborate with the federal Department of Labour to draft updated underground coal mining regulations applicable to all coal mines in Nova Scotia. These common regulations would then be administered throughout the province by the inspectorate at present functioning under the provisions of the Canada Labour Code regulations. Such regulations should be drafted with the advice and assistance of competent coal mining professionals with demonstrated expertise in the various fields of ventilation, ground control, electrical applications, training, and mine rescue. [Westray Page 542]
		A legislative regime should be put in place to ensure regulatory involvement in all areas of ground control in which safety is a consideration. The regime should encompass planning approval, materials and equipment certification, and any other aspect of ground control having safety implications. [Westray Page 383]
		The legislation governing coal mines should be revised to ensure that every underground coal mine operator be required to engage, when required, the services of a qualified mining engineer with specialized post-graduate training in rock mechanics relating to coal mines. [Westray Page 385]
	2006	Future regulations must focus first on the health and safety benefits they afford miners. Considerations regarding cost benefits should not in any way negatively impact the protections miners enjoy. [Sago Page 17]
		In addition to the recommendations already made in this report and the MINER Act, MSHA must immediately take the following actions: Repeal the belt-air regulation; Require flame resistant conveyor belts in all mines; Move to increase the number and skill level of mine rescue teams; Lower the maximum exposure limit for respirable coal mine dust and silica; Update and expand training and retraining of miners; Develop a public hearing- style investigation process; Update the penalty and assessment scheme; Modify the conferencing process; Improve the certification and approval process; Assist NIOSH in developing the next generation SCSRs; Update permissible exposure limits for contaminants in the mine environment; Improve atmospheric monitoring systems; Develop a nationwide emergency communications system; Develop air quality, chemical substances and respiratory protection standards; and Address issues related to working in confined spaces. [Sago Page 17]
	2011	The current law, which states that no mine operator or anyone else should provide advance notice for federal mine safety and health inspectors, should be strengthened. Such a violation should constitute a felony. [Upper Big Branch Page 111]
	2012	The activities of the New Zealand Mines Rescue Service need to be supported by legislation: The Mines Rescue Trust Act 1992 should reflect the functions performed by the Mines Rescue Service; and The adequacy and fairness of the current levies imposed on mines to fund the service need to be reviewed. [Pike River II Page 355]
		Worker participation in health and safety in underground coal mines should be improved through legislative and administrative changes. Legislative changes should:require operators of underground coal mines to have documented worker participation systems; ensure all workers, including contractors, are competent to work safely, are supervised and are included in the mine's worker participation system; empower trained worker health and safety representatives to perform inspections and stop activities where there is an immediate danger of serious harm; require the results of monitoring and investigation of health and safety in the workplace to be automatically made available to workers; and allow unions to appoint check inspectors with the same powers as the worker health and safety representatives. The regulator should: issue an approved code of practice on employee participation; promote workers' rights and obligations through education and publicity; and ensure that inspectors routinely consult workers and health and safety representatives as part of audits and inspections. [Pike River II Page 336-337]
	5.3	The Ministry of Labour and its partners to review the health and safety system's ability to meet the needs of the mining sector especially related to providing services to remote communities, training small numbers of trainees, and aligning their training

		activities to the priority hazards. Take appropriate actions based upon the findings of that review.
	5.4	The Ministry of Labour to work with the Ministry of Community Safety and Correctional Services to enhance the information supplied to the Chief Coroner's Office and build better linkages between both ministries. This collaboration includes: • Conducting and regularly updating an aggregate analysis of all past inquests into mining fatalities • Holding information sessions with the Chief Coroner to identify opportunities for coroners to use the analysis to improve future inquests into fatalities in the mining sector
Internal Responsibility System	**6.1**	The Ontario Mining Association to work with labour representatives to develop an Internal Responsibility System best practice guideline as an industry benchmark and to be endorsed by the Ontario Mining Association for implementation by its members.
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	1986	That the Ministry of Labour review and monitor the regional stability affecting underground mines in Ontario, and discuss potential problems with the mining companies involved. [Ground Control & Mine Rescue Page 61]
		That mining companies sharing a common boundary exchange information that may affect the regional stability of either or both. [Ground Control & Mine Rescue Page 61]
		That workplace mining plans be made available to miners and be discussed with them, including any indications of abnormal ground conditions, geological anomalies, and the location of ground monitoring instruments, as a method of ensuring worker participation in planning ground control procedures in the "micro" environment. [Ground Control & Mine Rescue Page 61]
		That every underground mine be required to prepare a ground control macro-environment design prior to the introduction of a new mining method, or the introduction of any expansion of the present mine design; such designs shall be submitted to the Ministry of Labour as required by Section 5 of the Mining Regulations. [Ground Control & Mine Rescue Page 60]
		That technically competent personnel of the Ministry of Labour review ground control design and procedures at all Ontario mines, at the mine site, at least once per year, and more frequently as required. [Ground Control & Mine Rescue Page 60]
		This organization shall be funded by mining companies operating in Ontario, and by the federal and provincial governments. [Ground Control & Mine Rescue Page 51]
	6.2	The health and safety system to share information both on emerging injury and illness trends, and information on incidents causing serious injury across the industry to trigger preventative actions by workplace parties.